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THE JOURNAL and CERAMIC ABSTRACTS, JULY, 1938

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A DECADE OF RESEARCH ON THE NATURE OF CLAY

By Paul F. Kerr

The Edward Orton, Jr., Memorial Lecture, American Ceramic Society, presented at the Fortieth Annual Meeting, American Ceramic Society, New Orleans, La., March 30, 1938.
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I. Introduction

The last decade has witnessed a great increase in our knowledge of clay. During this short era the most fundamental clay minerals have been largely established; progress has been made in a better understanding of processes of origin; the internal structures of clay minerals have been determined; explanations have been offered for many differences in physical properties and chemical behavior; and many obsolete clay mineral names have been eliminated.

Modern studies demonstrate that clays are made up of recognizable minerals. The interpretative logic formerly restricted to more coarsely crystalline material is these days being applied to the fine constituents of clays. The era just closed opens the door to a new era in which the technological utilization of clays may show great advance due to the basic studies of recent years.

In the early stages of clay mineral investigation, in the absence of other available forms of study, chemical methods were used almost exclusively. The use of these methods alone led to a confusing list of clay mineral names. Impurities in clays, in most cases inseparable, were frequently not distinguished. Differences and similarities in internal structure went unrecognized. The same clays from different localities were occasionally assigned different mineral names, or clays structurally different were thought to be the same.

The problem of the modern study of clay minerals involves a threefold approach. Owing to the finely crystalline character of virtually all clays, specialized methods of optical investigation are indispensable. Reliable chemical analyses and dehydration curves are also essential. Owing to the lack of measurable crystals and because of the importance even of slight differences in crystallization, X-ray diffraction patterns are of great value. On account of the necessary technique, the identification of most clays is essentially a laboratory problem. On the other hand, geological conditions of occurrence and careful field studies are even more important now than before laboratory methods reached the present stage of refinement. Determinations of origin, distribution, and purity depend in a large measure upon field studies.

The optical methods now in use involve the technique developed in recent years by E. S. Larsen, C. S. Ross, H. E. Merwin, and other students of optical mineralogy. Through the application of these methods, the optical constants of finely crystalline clays in many cases may be accurately determined. The textural relationships of the clay minerals and the distribution of impurities in clays may also be studied through the improvements in the technique of preparing and studying thin sections of soft, friable materials.

Although analytical methods have not changed in proportion to the developments in other fields, the exercise of greater care in hydration curves has resulted in revised interpretations of the ever-present water content of clays. Care in the investigation of the loss of water on dehydration has produced curves which may be satisfactorily correlated with curves showing variations in optical constants.

One of the greatest aids to the study of the clay minerals has come through the application of the methods of X-ray diffraction. Owing to such methods now generally used in a number of institutions in the United States and abroad, the nomenclature of clays has been greatly simplified. The application of X-ray studies to clays has grown so much since it was first started that, at the present time, not only have the most important clay minerals been substantiated by X-ray methods carried on independently by several investigators but tentative structures have been assigned to outstanding members of clay mineral groups.

II. Classification of the Clay Minerals

The classification of the clay minerals in Table I represents a survey of the cumulative work of a number of investigators throughout the last

TABLE I

THREE GROUPS OF HYDRATED MINERAL CONSTITUENTS COMMON IN CLAY

Group	Mineral	Chemical constituents	Structural type (lattice)
Kaolin	Nacrite	$Al_2O_3 \cdot 2SiO_2 \cdot 2H_2O$	Nacrite
	Dickite	$Al_2O_3 \cdot 2SiO_2 \cdot 2H_2O$	Dickite
	Kaolinite	$Al_2O_3 \cdot 2SiO_2 \cdot 2H_2O$	Kaolinite
	Anauxite	$Al_2O_3 \cdot 3SiO_2 \cdot 2H_2O$	
	Halloysite	$Al_2O_3 \cdot 2SiO_2 \cdot 2H_2O$	Halloysite
	Allophane	$Al_2O_3 \cdot nSiO_2 \cdot nH_2O$	No regular lattice
Montmorillonite	Montmorillonite	$(MgCa)O \cdot Al_2O_3 \cdot 5SiO_2 \cdot nH_2O$	Montmorillonite
	Beidellite	$Al_2O_3 \cdot 3SiO_2 \cdot nH_2O$	
	Nontronite	$(Al, Fe)O_3 \cdot 3SiO_2 \cdot nH_2O$	
	Saponite	$2MgO \cdot 3SiO_2 \cdot nH_2O$	
Alkali-bearing clay (minerals not yet established)	Metabentonite	K_2O–MgO–Al_2O_3–SiO_2–H_2O in variable amounts	Modified mica
	Clay mica		

decade and, in part, a few years beyond. The names established are based upon X-ray studies, optical methods, and chemical analyses. While perhaps subject to differences of opinion in minor respects, on the whole it is believed that the choice of names and groups represents a proper classification of the clay minerals in the light of most recent evidence.

The three groups outlined may be used conveniently in classifying the clay minerals from the standpoint of origin. The processes responsible for the formation of different members of the groups vary considerably, emphasizing the importance of the divisions.

The origin of the kaolin group has long been studied and even before modern methods of identification were developed many excellent contributions concerning the processes involved in forming kaolin existed. In some instances, the interpretations have suffered on account of uncertainty concerning the identity of the particular clay mineral described. In many instances, however, little doubt exists concerning the identity of the mineral described, and it is possible to utilize directly the earlier conclusions regarding origin. Old identifications may be frequently reinterpreted in terms of more recent descriptions and identifications.

The origin of the minerals of the montmorillonite group, not clearly established by early work, has recently received extensive study. The minerals of the group are now fairly well known, and much information has been developed concerning their formation in nature.

The alkali-bearing clays are least known and less certainly established, both as to identity and origin. Extensive study of the mineral constituents will be required before names and mineral variations may be properly applied.

III. Kaolin Group

Study of the kaolin group has demonstrated that a number of different crystalline structures exist having the same chemical composition[1] (Table II). The names nacrite, dickite, kaolinite, and halloysite[2] have been applied. Allophane is the amorphous member of the kaolin group. Names such as clayite,[3] indianaite,[2] leverierrite,[1(a)] newtonite,[4] and others have been shown to represent mixtures of kaolin minerals or mixtures of kaolin and other minerals.

(1) Nacrite ($Al_2O_3 \cdot 2SiO_2 \cdot 2H_2O$) (Monoclinic)

The name *nacrite* was reserved for the original material described under that name[5] occurring at Brand, Saxony, and also found in other localities.[6] Nacrite, because of a higher temperature of dehydration than observed for other clay minerals, is thought to be formed at temperatures above other minerals of the kaolin group. Only a few occurrences of nacrite are on record. In

[1] (*a*) C. S. Ross and P. F. Kerr, "The Kaolin Minerals," *U. S. Geol. Surv. Prof. Paper*, No. 165E, pp. 151–80 (1931).
(*b*) S. B. Hendricks and W. H. Fry, "Results of X-Ray and Microscopical Examinations of Soil Colloids," *Soil Sci.*, **29**, 457–79 (1930).

[2] C. S. Ross and P. F. Kerr, "Halloysite and Allophane," *U. S. Geol. Surv. Prof. Paper*, No. 185G, pp. 135–48 (1934); *Ceram. Abs.*, **14** [4] 101 (1935).

[3] H. Ries, Clays, Their Occurrences, Properties, and Uses, p. 70, 3d ed. John Wiley & Sons, Inc., New York, 613 pp., 1927; *Ceram Abs.*, **6** [10] 485 (1927).

[4] W. F. Foshag, "Identity of Newtonite with Alunite," *Amer. Mineral.*, **11**, 33–35 (1926).

[5] A. Breithaupt, Vollständige Charakteristik des Mineral-Systems, pp. 94, 318 (1832).

[6] Whitman Cross and W. F. Hillebrand, "Minerals from the Neighborhood of Pike's Peak, Colorado," *U. S. Geol. Surv. Bull.*, No. 20, pp. 41–42, 67–68 (1885).

TABLE II

TABLE OF INTERPLANAR SPACING IN ANGSTROM UNITS FOR NACRITE, DICKITE, AND KAOLINITE, AS GIVEN IN THE ORIGINAL DESCRIPTION OF DICKITE

Nacrite*			Dickite*			Kaolinite*		
Arc (mm.)	Spacing (Å $\times 10^{-8}$ cm.)	Estimated int.	Arc (mm.)	Spacing (Å $\times 10^{-8}$)	Estimated int.	Arc (mm.)	Spacing (Å $\times 10^{-8}$)	Estimated int.
18.3	4.471	8	18.3	4.471	8	18.3	4.464	10
19.5	4.201	5	19.5	4.201	5	19.5	4.194	10
22.6	3.621	9	21.3	3.846	5	21.1	3.874	5
24.25	3.371	4	22.55	3.631	9	22.6	3.614	6
26.4	3.101	3	23.5	3.491	2	23.9	3.424	5
32.2	2.541	5	24.6	3.336	0.5	25.8	3.069	2
33.8	2.425	10	25.9	3.161	0.5	29.3	2.789	1
35.1	2.335	4	27.5	2.981	2	32.6	2.512	9
39.1	2.095	4	28.8	2.741	2	34.8	2.344	10
41.4	1.980	5	31.6	2.591	5	35.6	2.305	4
42.7	1.920	5	32.4	2.526	8	37.2	2.205	1
45.1	1.820	2	34.0	2.408	1	41.0	2.005	4
49.3	1.671	5	35.0	2.346	10	44.3	1.860	1
55.5	1.480	9	36.9	2.225	2	49.4	1.666	6
56.6	1.450	3	41.2	1.995	8	50.6	1.621	2
60.0	1.368	4	42.9	1.910	1	53.1	1.549	2
62.5	1.318	1	43.9	1.870	2	55.3	1.487	6
65.4	1.273	4	45.6	1.800	1	56.6	1.455	2
67.2	1.230	2	49.7	1.659	9	59.4	1.382	1
68.5	1.209	5	52.7	1.564	5	61.6	1.347	5
70.1	1.179	1	55.2	1.494	8	63.4	1.303	2
72.9	1.134	0.25	56.2	1.469	2	64.4	1.283	3
75.8	1.094	0.25	57.4	1.434	0.5	66.9	1.233	4
76.8	1.079	0.25	58.6	1.409	1	68.8	1.203	0.5
80.8	1.028	0.5	59.7	1.383	1	71.3	1.164	0.25
87.0	0.959	0.5	62.4	1.323	8	74.5	1.114	0.25
91.9	0.910	0.25	63.9	1.293	3	76.5	1.084	0.25
98.1	0.854	0.25	65.7	1.258	4	79.8	1.041	0.25
101.2	0.833	0.25	66.9	1.236	4	82.1	1.013	0.25
106.0	0.798	0.25	69.4	1.190	3	87.9	0.951	0.5
115.7	0.737	0.25	71.6	1.159	0.5	94.3	0.889	0.5
121.0	0.707	0.25	75.0	1.109	2	98.0	0.858	0.25
			77.1	1.077	1	100.7	0.838	0.25
			80.3	1.032	2	106.1	0.797	0.25
			83.9	0.995	1			
			87.0	0.960	1			
			89.8	0.930	1			
			94.4	0.879	2			
			97.6	0.859	0.25			
			99.9	0.842	0.25			
			102.5	0.820	0.5			
			110.6	0.765	0.25			
			115.6	0.735	0.25			

* Corrected against sodium chloride (100) = 2.814 Å (measurements in millimeters are given as read on film. Å measurements include a small correction based on sodium chloride).

the most outstanding of these, the mineral has been found in association with metallic ore minerals. Although chemically related to the clay minerals, nacrite has not yet been found in large deposits typical of common clays.

(2) Dickite ($Al_2O_3 \cdot 2SiO_2 \cdot 2H_2O$) (Monoclinic)

Owing to failure to distinguish two unlike crystalline compounds until recent years, two different minerals had been called kaolinite; hence, in modern studies it has been necessary to apply a different name to one species. The name *dickite* was selected in appreciation of the excellent description of the kaolinite from Anglesey furnished by Dick.[7]

Dickite is thought to be formed normally at temperatures lower than those prevailing for nacrite. It is probably a hydrothermal mineral, although some occurrences of dickite suggest lower temperature conditions of formation. Dickite from Morococha, Peru, and from Anglesey occurs associated with metallic sulfides. In the Morococha occurrence, it forms a crust on crystals of

[7] (*a*) A. B. Dick, "On Kaolinite," *Mineralog. Mag.*, **8**, 15–17 (1888).
(*b*) A. B. Dick, "Supplementary Notes on the Mineral Kaolinite," *ibid.*, **15**, 124–27 (1908).

enargite. Recently, dickite has been described from southeastern Missouri,[8] occurring along with

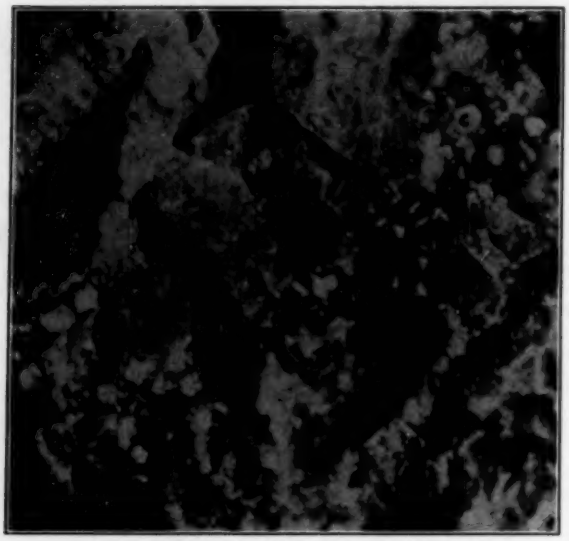

FIG. 1.—Dickite crystals (*C*) on dolomite crystals (*B*) from southeastern Missouri; ×15 (photo by J. G. Grohskopf and Mary Hundhausen).

fluorite and minor amounts of sulfides. The nearest known igneous rocks, laterally at least, are dikes reported to be some twenty miles distant. At this locality, dickite has been reported both near the surface and at a depth of 3000 feet. Considerable masses of dickite occur near Cusihuiriachic, Chihuahua, Mexico.[10a] Extensive rock alteration at this locality, shown in specimens recently secured, suggests hydrothermal conditions of formation. With one or two possible exceptions, dickite does not appear to have been reported from deposits where origin due to weathering is established.

(3) Kaolinite ($Al_2O_3 \cdot 2SiO_2 \cdot 2H_2O$), Anauxite ($Al_2O_3 \cdot 3SiO_2 \cdot 2H_2O$) (Monoclinic)

The name *kaolinite* has been applied to the most commonly occurring kaolin mineral of ceramic importance. In the group of minerals having identical composition but differing in structure, kaolinite offers an additional manner of variation. It is possible for the silica content of kaolinite to vary in considerable amount without apparently producing a change in structure. The compound having an alumina-silica ratio of 1:3, as shown by chemical analysis, has been called *anauxite*.

The word *anauxite* has been applied to a form of kaolin found as an alteration of pyroxene in Bilin, Czechoslovakia.[9] This material was re-

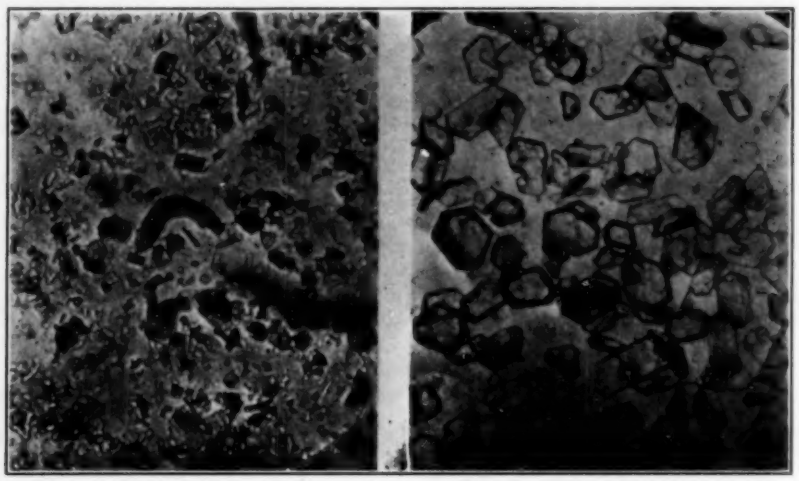

FIG. 2 (*left*).—Kaolinite crystals from Franklin, N. C.; ×350 (photo by C. S. Ross).
FIG. 3 (*right*).—Dickite crystals from Red Mountain, Colo.; ×260 (photo by C. S. Ross).

studied by Foshag and Ross.[10] Later their

[8] J. G. Grohskopf and Mary Hundhausen, "Occurrence of Dickite and Fluorite in the Cambrian and Ordovician of Perry County, Missouri," *Mo. Geol. Surv. and Water Resources, Appen. III, 59th Bien. Rept.*, 13 pp., 1937.

[9] E. Dittler and J. E. Hibsch, "Über Anauxite und Cimolite von Bilin," *Mineralog. Petrog. Mitt.*, **36**, 85–91 (1927).

[10] C. S. Ross and W. F. Foshag, "Anauxite, a Mineral Species Based on Material from Bilin, Czechoslovakia," *Amer. Mineral.*, **13**, 153–55 (1928).

identification was confirmed by X-ray diffraction patterns,[11] and since that time X-ray and optical measurements have been confirmed by other investigators in connection with the examination of kaolinite[12] and anauxite.[13]

Kaolinite and anauxite appear to be formed under similar conditions; hence no distinction need be made between the two in the discussion of origin. The name kaolinite will be used, although it should be borne in mind that the same conditions apply to anauxite.

Kaolinite appears to be formed for the most part by essentially low-temperature processes although, in a few instances, rather deep-seated occurrences have been found, suggesting the possibility of dying-out hydrothermal activity. Kaolinite formed at Silver Dyke[14] and Goldfield,[15] by Ries,[16] Bayley,[17] and others[18] in their discussion of the kaolin deposits of the eastern and southeastern United States. In general, these kaolins fall into two classes, *viz.*, residual kaolins formed by weathering of feldspathic rocks and the sedimentary kaolins representing accumulations of weathered material transported some distance from the original source.[19] Kaolin has also been considered to be produced in a number of deposits by the action of sulfuric acid derived from the decomposition of pyrite and acting upon aluminous materials. Kaolinite formed in this way is apt to be associated with alunite and is also likely to be mixed with a substantial quantity of halloysite.

Kaolinite is thought to be formed in some places

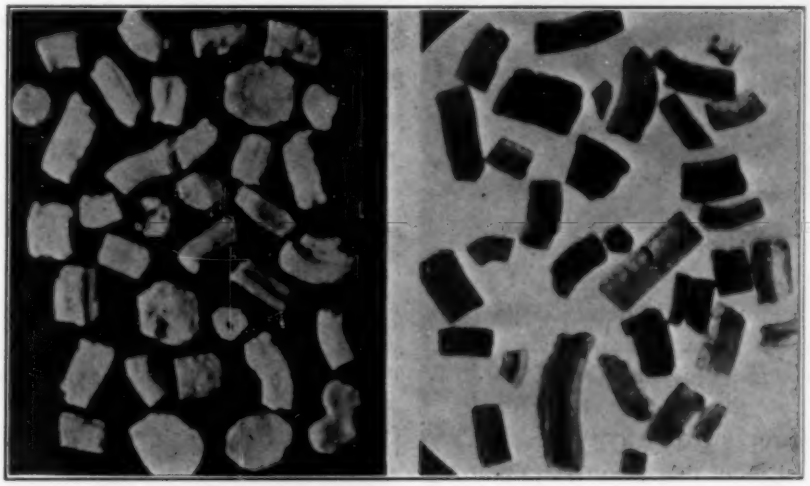

FIG. 4 (*left*).—Kaolinite crystals from Ione, Calif.; ×10 (photo by C. S. Ross).
FIG. 5 (*right*).—Kaolinite crystals from Pontiac, S. C.; ×28 (photo by C. S. Ross).

Nevada, may be of this type. The more important occurrences, however, have been produced as a product of weathering, as ably demonstrated by the decomposition of aluminous rocks,[20] hastened by the solvent action of acids derived

[11] (*a*) C. S. Ross and P. F. Kerr, "Clay Minerals and Their Identity," *Jour. Sedimentary Petrology*, **1**, 55–65 (1931).
(*b*) See also footnote reference 1.
[12] G. Nagelschmidt, "Röntgenographische Untersuchungen an Tonen," *Z. Krist.*, **87** [1–2] 120–45 (1934); *Ceram. Abs.*, **14** [4] 100 (1935).
[13] S. B. Hendricks, "Diffraction of X-Radiation from Some Crystalline Aggregates," *Z. Krist* **71**, 269–73 (1929).
[14] P. F. Kerr, "Tungsten Mineralization at Silver Dyke, Nevada," *Univ. of Nevada Bull.*, **30** [5] 70 pp. (1936).
[15] F. L. Ransome, "Association of Alunite with Gold in the Goldfield District, Nevada," *Econ. Geol.*, **2**, 689–90 (1907).
[16] H. Ries, "Review of Theories of Origin of White Residual Kaolins," *Trans. Amer. Ceram. Soc.*, **13**, 51–74 (1911).
[17] W. S. Bayley, "High-Grade Clays of the Eastern United States," *U. S. Geol. Surv. Bull.*, No. 708, p. 41 (1921).
[18] (*a*) Waldemar Lindgren, "Origin of Kaolin," *Econ. Geol.*, **10**, pp. 90, 91, 93 (1915).
(*b*) Edward Orton, "Clays of Ohio, Their Origin, Composition, and Varieties," *Ohio Geol. Surv.*, No. 7, 45–68 (1893).
[19] E. R. Lilley, "Geology of Some Kaolins of Western Europe," *A.I.M.M.E. Tech. Pub.*, No. 475, 22 pp. (1932).
[20] P. F. Kerr, "Kaolinite from a Brooklyn Subway Tunnel," *Amer. Mineral.*, **15**, 144–58 (1930).

by the decay of organic material.[21] At times, carbonate waters are also effective. The flint clays of Gasconade County, Missouri, are thought by Allen[22] to be formed in this way; he also described diaspore and bauxite, produced at different stages of the same process. McQueen[23] has suggested that the flint clays formed a gradational series of some continuity and areal extent which, after deposition, slumped or caved into sink holes formed by the solution of the underlying dolomitic limestones. Lapparent has also described kaolin formed in association with

FIG. 6.—Kaolinite (above) and altered granitic rock (below) from Newtown Creek, Long Island, N. Y.

bauxite and diaspore.[24] The deposits described by Lapparent contain, in addition, the unusual monohydrate of aluminum, *boehmite*. Crystals of boehmite have been described as coating walls of cavities, the interiors of the cavities being filled with kaolin. Correns[25] has also referred to the influence of carbon dioxide and organic acids in the formation of kaolin.

Although kaolin may be produced in other ways, it seems that, in general, the processes include the last stages of hydrothermal alteration, supergene weathering *in situ* or accompanied by transportation and redeposition, the action of waters bearing sulfuric acid, and the combined action of carbonate waters and organic acids.

(4) Halloysite ($Al_2O_3 \cdot 2SiO_2 \cdot 2H_2O$)

Halloysite was first described by Berthier,[26] who named the mineral after Omalius d'Halloy. The type material was found in the vicinity of Liége, Belgium. This material was restudied in 1931 and found to be distinguishable optically and crystallographically from kaolinite, although similar chemically.[2] Later, Mehmel[27] indicated that two varieties of halloysite appeared to exist, one a form chemically similar to kaolinite called *metahalloysite*, another containing a larger amount of water which he called *halloysite*. Hendricks[28] has since restudied halloysite and has recently suggested that the more hydrous form should be called *hydrohalloysite*, reserving the name *halloysite* for the less hydrous type of the mineral.

FIG. 7.—Halloysite with shatter cracks containing alunite and small spherulitic areas believed to be gibbsite; ×27.

Common specimens belong to this somewhat dehydrated type. Halloysite probably belongs to

[21] (*a*) V. Špalek, "Genesis and Age of Kaolins near nojmo, South Moravia," *Veda Přírodní*, **17**, 202–206 (1936).
(*b*) Floyd Hodson, "Origin of Bedded Pennsylvanian Fire Clays in the United States," *Jour. Amer. Ceram. Soc.*, **10** [9] 721–46 (1927).

[22] V. T. Allen, "Mineral Composition and Origin of Missouri Flint and Diaspore Clays," *Mo. Geol. Surv. and Water Resources, Appen. IV, 58th Bien. Rept.*, pp. 19–21 (1935).

[23] H. S. McQueen, "Geologic Relations of Diaspore and Flint Fire Clays of Missouri," *Jour. Amer. Ceram. Soc.*, **12** [10] 687–97 (1929).

[24] Jacques de Lapparent, "Boehmite and Diaspore in Bauxitic Clays of Ayrshire," Summary of Progress of the Geol. Surv. for 1934 [Part II], pp. 1–7. H. M. Stationery Office, London, 1936.

[25] (*a*) C. W. Correns, "Petrographische Untersuchungen an Tonen," *Fortschr. Mineral., Krist., Petrog.*, **20**, 35–37 (1936).
(*b*) C. W. Correns, "Petrography of Clays," *Naturwissenschaften*, **24**, 117 (1936).

[26] P. Berthier, "Analyse d'Halloysite," *Ann. chim. phys.*, **32**, 332–35 (1826).

[27] M. Mehmel, "Beitrag zur Frage des Wassergehaltes der Minerale Kaolinit, Halloysit, und Montmorillonit," *Chem. Erde*, **11**, 1–16 (1937); *Ceram. Abs.*, **16** [8] 258 (1937).

[28] S. B. Hendricks, "Concerning the Crystal Structure of the Clay Minerals, Dickite and Halloysite" (abstract), *Amer. Mineral.*, **23**, 170 (1938).

the colloidal group of Wherry,[29] considered from the standpoint of particle size.

Halloysite is not commonly found entirely free from other clay minerals. It is most frequently associated with kaolinite, alunite, and various forms of hydrated aluminum oxides (Fig. 7). In the southeastern part of the United States, halloysite is apparently produced along with kaolin as a result of weathering processes. In one or two deposits, halloysite is said to be the most prominent constituent. Ordinarily, however, kaolin is much more prominent. Nagelschmidt[12] has described halloysite as a fine constituent of a Middle Oligocene clay from Mallis in South Mecklenburg. In a number of localities, halloysite is apparently produced by the action of waters containing sulfuric acid, as indicated by the fairly common association of alunite and halloysite. This association has been observed in Newton County, Arkansas[30]; Lawrence County, Indiana[31]; and near Liége, Belgium[2]; as well as in several other localities.[32] As far as is known at the present time, halloysite and hydrohalloysite occur together and under the same conditions. Compact, porcelainlike, more hydrous specimens of halloysite may exhibit a powderlike covering or, upon drying, the entire mass suffers a loss in water content.

Evidently change in water content in halloysite influences the refractive indices, because the more hydrous form has lower refractive indices. The variations of refractive indices with vapor pressure and temperature have been determined by Mehmel.[27] It is also interesting to note that the X-ray diffraction patterns show displacement of the (001) line, comparative measurements being 10.01 Å for the more hydrous form and 7.46 Å for the less hydrous form.

The relationship of water in halloysite and hydrohalloysite is somewhat comparable to the behavior of the water in montmorillonite, and it would seem that the water content of hydrohalloysite would be worthy of further study in view of recent contributions to the understanding of the behavior of water in montmorillonite.[33]

(5) Allophane ($Al_2O_3 \cdot nSiO_2 \cdot nH_2O$)

Allophane is thought by some to be the gel material forming as an intermediate product when kaolin is produced by the processes of weathering. Chemical studies carried on by Hofmann *et al.*,[34] Lehman and Neumann,[35] and others[36] show allophane to be present in kaolin. It seems likely that the mineral is a product of supergene action, either a result of weathering or of the action of waters carrying sulfuric acid. The presence of phosphorus pentoxide in substantial quantities in many samples of allophane as shown by analysis has not yet been thoroughly explained. It is indicative, however, of the rather complex nature of the mineral. It is a structureless material, comparable in many respects to the group of structureless minerals which includes opal free from impurities, chrysocolla, and collophane. These minerals have been termed amorphous by Rogers.[37]

IV. Montmorillonite Group

The montmorillonite group of clay minerals is one of the most widespread of the clay mineral groups from the standpoint of occurrence. The outstanding and apparently sufficiently substantiated species are montmorillonite, beidellite, nontronite, and saponite.

These minerals form a group of structural similarity. The crystal lattice varies in dimensions, but evidently retains the same arrangement throughout the group. Variations in the distribution of aluminum, ferric iron, calcium, and magnesium ions throughout the fundamental montmorillonite lattice appear responsible for the different mineral representatives.

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[29] E. T. Wherry, "Tabulation of Aluminum Silicate Minerals," *Amer. Mineral.*, **10**, 143–45 (1925); *Ceram. Abs.*, **4** [9]-261 (1925).

[30] See footnote references 2 and 4, p. 268.

[31] (*a*) H. Ries, "High-Grade Clays of the Eastern United States," *U. S. Geol. Surv. Bull.*, No. 708, p. 156 (1922).

(*b*) W. N. Logan, "A Bio-Chemical Theory of the Origin of Indianaite," *Science* [New Series], **49**, 197 (1919); "Kaolin of Indiana," *Indiana Dept. of Conserv., Div. of Geol. Pub.*, No. 6, pp. 35–76 (1919); *Jour. Amer. Ceram. Soc. (Abs.)*, **4** [5] 423 (1921).

(*c*) W. H. Bucher, "Logan's Explanation of Origin of Indiana's Kaolin," *Econ. Geol.*, **16**, 481–92 (1921).

[32] J. Kühl, "Formation of Kaolin and Alunite near Sandomierz, Poland," *Akad. Polon. Sci. Bull. Intern.*, Nos. 7–10A, pp. 665–75 (1931).

[33] W. F. Bradley, R. E. Grim, and G. L. Clark, "Study of Behavior of Montmorillonite upon Wetting," *Z. Krist.*, **97**, 216–22 (1937).

[34] U. Hofmann, K. Endell, and D. Wilm, "Röntgenographische und Kolloidchemische Untersuchungen über Ton," *Angew. Chem.*, **47** [30] 539–47 (1934); *Ceram. Abs.*, **14** [1] 24 (1935).

[35] H. Lehmann and W. Neumann, "Clay Substance: Contribution to the Judgment of Rational Analysis," *Ber. deut. keram. Ges.*, **12**, 327–63 (1931).

[36] See footnote reference 2, p. 268.

[37] A. F. Rogers, "Review of the Amorphous Minerals," *Jour. Geol.*, **25**, 515–41 (1917).

TABLE III
CHEMICAL ANALYSES OF DICKITE, NACRITE, AND HALLOYSITE

	Dickite			Nacrite		Halloysite		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
SiO_2	44.64	43.10	45.04	44.75	45.91	44.75	43.67	39.84
Al_2O_3	40.42	40.10	40.70	39.48	39.65	36.94	37.91	39.70
Fe_2O_3	0.32	0.64	Trace	0.53		0.31	0.26	0.64
MgO	0.05	0.20	Trace	0.19		?	Trace	0.14
CaO	0.34	0.24	0.22	0.13		0.11		0.40
H_2O-	0.04	1.08		0.61		2.53	3.79	1.76
H_2O+	13.98	14.82	14.08	14.40	13.77	14.89	14.50	17.52
TiO_2			Trace					
F								
CaF_2					0.68			
Na_2O								
K_2O						0.60		
P_2O_5							0.12	
Total	99.79	100.18	100.04	100.09	100.01	100.13	100.25	100.00

Dickite { (1) Greenwood, Sebastian County, Ark.
(2) "Pholerite," Neurode, Schlesien.
(3) Cusihuiriachic, Chihuahua, Mexico.

Analyses of (1) to (3) from C. S. Ross and P. F. Kerr, "The Kaolin Minerals," *U. S. Geol. Surv. Prof. Paper*, No. 165E, p. 160 (1931).

Nacrite { (4) Brand, Saxony.
(5) St. Peter's Dome, Colo.

Analyses of (4) and (5) from C. S. Ross and P. F. Kerr, *ibid.*, p. 158.

Halloysite { (6) Liége, Belgium.
(7) Huron County, Ind.
(8) Sneeds Creek, Newton County, Ark.

Analyses of (6), (7), and (8) from C. S. Ross and P. F. Kerr, "Halloysite and Allophane," *U. S. Geol. Surv. Prof. Paper*, No. 185G, p. 137 (1934).

It should also be pointed out that changes in the distribution and amounts of other ions affect the silica content. The water is in large part loosely held in the lattice. It is so loosely held, in fact, that samples of montmorillonite may be shown to vary perceptibly in water content with the humidity of the atmosphere.

(1) Montmorillonite $(MgCa)O \cdot Al_2O_3 \cdot 5SiO_2 \cdot n\text{-}H_2O)$

The name *montmorillonite* was first applied to a pinkish clay found at Montmorillon, France, by Damour and Salvetat[38] in 1847. It is a hy-

[38] Damour and Salvetat, "Notice and Analyses of a Hydrosilicate of Aluminum Found at Montmorillon," *Ann. Chim. Phys.*, [3d Series], **21**, 376 (1847).

TABLE IV
CHEMICAL ANALYSES OF ANAUXITE AND KAOLINITE

	Anauxite				Kaolinite			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
SiO_2	54.32	52.46	48.80	44.70	44.92	44.26	54.73	46.44
Al_2O_3	29.96	32.20	35.18	38.64	40.22	40.22	38.37	36.36
Fe_2O_3	2.00	1.69	1.24	0.96	0.54	0.30	0.40	1.25
MgO	0.14	0.00	0.00	0.08	0.14	0.18	0.00	0.18
CaO	0.32	0.03	0.22	0.24	0.08	0.32	0.56	0.28
Na_2O	0.37	0.25	0.25	0.62			0.00	0.42
K_2O	0.00	0.31	0.40	0.14			0.00	1.50
H_2O-	0.84	1.38	1.16	0.64	0.08	0.64	0.50	0.69
H_2O+	11.80	12.07	12.81	13.88	14.22	14.16	13.19	11.46
TiO_2		0.55	0.61	0.22		0.00	1.35	0.84
MnO				0.00		0.00		0.03
SO_3							0.16	
Total	99.75	100.94	100.67	100.12	100.20	100.08	100.26	99.45

Anauxite { (1) Bilin, Czechoslovakia.
(2) Mokelumne River, Lancha Plana, Calif.
(3) Newman Pit, Ione, Calif.
(4) Ione, Amador County, Calif.

Kaolinite { (5) United Verde Extension Mine, Jerome, Ariz.
(6) Franklin, N. C.

Analyses of (1) to (6) from C. S. Ross and P. F. Kerr, "The Kaolin Minerals," *U. S. Geol. Surv. Prof. Paper*, No. 165E, p. 163 (1931).

Kaolinite { (7) Newtown Creek, Long Island, N. Y. P. F. Kerr, "Kaolinite from a Brooklyn Subway Tunnel," *Amer. Mineral.*, **15**, 153 (1930).
(8) Staten Island, New York. P. F. Kerr, "Kaolinite from the Terminal Moraine of Staten Island," *ibid.*, **17**, 32 (1932).

drous aluminum silicate containing substantial amounts of calcium and magnesium. Until recent years, a number of other examples of this pinkish clay had been found, usually occurring as an alteration product in pegmatite dikes. About 1920, similar clays from various localities in the western United States, subsequently shown to

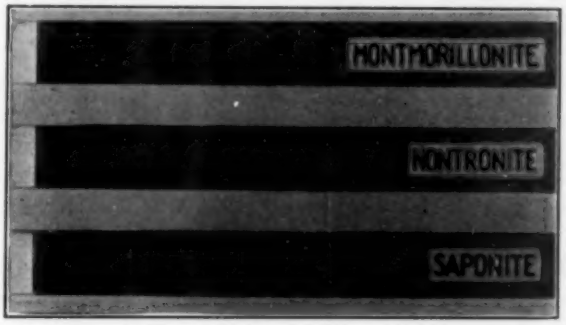

FIG. 8.—X-ray diffraction patterns of members of the montmorillonite group, showing variations of lines both in intensity and spacing.

contain substantial amounts of montmorillonite, were first used for purifying oil. At the same time, the word *bentonite* was applied to mineralogically similar clays occurring in Wyoming, and also used commercially, in part, for similar purposes. The name "montmorillonite" was applied in some instances and "bentonite" in others, even

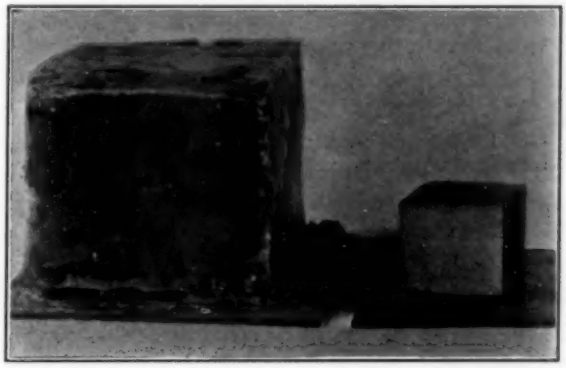

FIG. 9.—Bentonite; the small cube is dry; the large cube is the same cube after taking up all the water it would hold and still retain its form (photo by H. S. Spence).

in the same locality. Both were then considered as mineral names. Bentonite had been proposed as a mineral name by Knight[39] after *taylorite*, a name suggested earlier,[40] had been found to be already in use for another mineral. Inasmuch as the clay was found near Benton and in the Benton formation, the name was appropriate geographically for a rock type, but not mineralogically, as it consisted essentially of the mineral montmorillonite. In 1925, Ross and Shannon[41] made a comprehensive study of such clays, investigating material from numerous localities. The clays were found to contain montmorillonite and, in some cases, beidellite, mineral names deserving recognition on account of priority. Bentonite was suggested as a rock name to be applied to clays formed by the alteration of volcanic ash and containing substantial amounts of the minerals, montmorillonite or beidellite. In addition, montmorillonite and beidellite were clearly es-

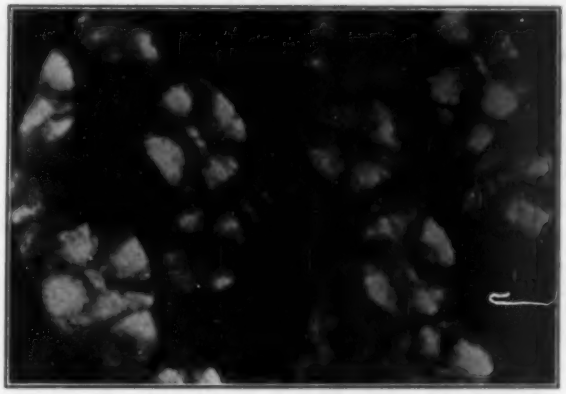

FIG. 10.—Spherulites of synthetic beidellite; ×1400, crossed-nicols (photo by H. Insley and R. H. Ewell).

tablished as minerals, and the chemical composition and optical properties were determined. X-ray studies shortly afterward confirmed the identification.[42]

Montmorillonite is one of the most widespread of clay minerals. The original ash may have accumulated either in terrestrial,[43] lacustrine, or marine deposits. It occurs in many bentonitic areas in the western United States, in numerous

[39] W. C. Knight, "Mineral Soap," *Eng. Mining Jour.*, **63**, 600–601 (1897).

[40] W. C. Knight, "Bentonite (Wyoming)," *ibid.*, **66**, 491 (1898).

[41] C. S. Ross and E. V. Shannon, "Minerals of Bentonite and Related Clays and Their Physical Properties," *Jour. Amer. Ceram. Soc.*, **9** [2] 77–96 (1926).

[42] (*a*) C. A. Bonine, "Recent Work on Bentonite," *Nat. Research Council, Rept. of Comm. on Sedimentation*, p. 15 (1928).
(*b*) P. F. Kerr, "Bentonite from Ventura, California," *Econ. Geol.*, **26**, 153–68 (1931).

[43] J. B. Tenney, "Second Report on Mineral Industries of Arizona," *Ariz. Bur. Mines Bull.*, No. 129, p. 93 (1930).

European localities, and probably in many other parts of the world. The mineral is also thought to be an essential constituent of the more important deposits of efficient decolorizing clays and fullers' earths.[44] Kaolinite may be occasionally used as a decolorizing agent,[45] but is not as suitable in this way as most montmorillonite. The origin of montmorillonite as an alteration product of volcanic ash has been well established, but the processes which bring about this alteration are not as well known. It seems likely, however, that the action of sulfuric acid derived from the decomposition of pyrite in overlying strata may account for the formation of the mineral in some places. Elsewhere, it seems more likely that carbonate waters accompanied by organic acids may have caused the formation of montmorillonite somewhat in the same way that kaolin is produced by the alteration of feldspars. Gruner[46] has also shown that montmorillonite may be synthetically produced by the hydrothermal alteration of feldspar. Montmorillonite produced by weathering has been described by Woodford.[47] It seems possible, as indicated by the work of Kelley,[48] that marine clays containing montmorillonite held for substantial periods in contact with salt water take up a considerable amount of magnesium. The magnesium content of montmorillonite clays shown to have been subjected to the percolation of marine waters is worthy of further study.

One of the interesting by-products of the formation of montmorillonite in a number of localities is the zeolite identified by Bramlette[49] as *clinoptilolite*. This zeolite is thought to form in some places as an intermediate product during the alteration of volcanic glass to montmorillonite. Zeolites have been observed in montmorillonite clays from Wyoming, California, and Utah.[50]

Recently, the mineral montmorillonite, on account of its remarkable base exchange capacity and because of the unusual character of the water it contains, has been studied intensively. Hofmann and associates,[51] Marshall,[52] Kelley,[53] and others have been particularly interested either in the swelling of montmorillonite due to water or in chemical variations due to base exchange capacity. Crystal structures have been proposed for this mineral. Montmorillonite has been identified as one of the chief soil colloids.[54] Confirmation of this work has appeared from several independent sources, both in this country and abroad, and it appears to be fairly well established.

(2) Beidellite ($Al_2O_3 \cdot 3SiO_2 \cdot nH_2O$)

In 1916, a clay gouge was discovered by Larsen in the course of geological studies in the San Juan Mountains near Beidell, Colorado.[55] The clay occurs in pockets several feet across in association with gold-silver-bearing ores in the Buckhorn and Esperanza mines. The clay was described by Larsen and Wherry, who identified it as *leverrierite*, although Dana, previously,[56] and Cayeux,[57]

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[44] (*a*) P. F. Kerr, "Montmorillonite or Smectite as Constituents of Fullers' Earth and Bentonite," *Amer. Mineral.*, **17**, 192–98 (1932).
(*b*) P. F. Kerr and E. N. Cameron, "Fullers' Earth of Bentonitic Origin from Tehachapi, California," *ibid.*, **21** [4] 230–37 (1936); *Ceram. Abs.*, **15** [6] 189 (1936).
(*c*) P. F. Kerr, "Attapulgus Clay," *Amer. Mineral.*, **22** [5] 543 (1937); *Ceram. Abs.*, **17** [1] 35 (1938).
(*d*) R. E. Grim, "Petrography of Fullers' Earth Deposits, Olmstead, Illinois, with a Brief Study of Some Non-Illinois Earths," *Econ. Geol.*, **28** [4] 344–63 (1933); *Ceram. Abs.*, **13** [2] 49 (1934).
(*e*) H. Longchambon, "Constituants Minéralogiques Essentiels des Argiles, en Particulier der Terres à Foulon," *Compt. rend.*, **201** [10] 483–86 (1935); *Ceram. Abs.*, **15** [1] 39 (1935).

[45] R. J. Piersol, J. E. Lamar, and W. H. Voskuil, "Anna 'Kaolin' as a New Decolorizing Agent for Edible Oils," *Ill. State Geol. Surv. Rept. of Invest.*, No. 27, 42 pp. (1933).

[46] J. W. Gruner, "Hydrothermal Alteration of Montmorillonite to Feldspar at Temperatures from 245° to 300°C," *Amer. Mineral.*, **21** [8] 511–15 (1936); *Ceram. Abs.*, **16** [1] 39 (1937).

[47] J. D. Laudermilk and A. O. Woodford, "Secondary Montmorillonite in a California Pegmatite," *Amer. Mineral.*, **19** [6] 260–67 (1934); *Ceram. Abs.*, **14** [2] 49 (1935).

[48] W. P. Kelley and G. F. Liebig, Jr., "Base Exchange in Relation to Composition of Clay with Special Reference to Effect of Sea Water," *Bull. Amer. Assn. Petroleum Geol.*, **18** [3] 358–67 (1934); *Ceram. Abs.*, **13** [8] 222 (1934).

[49] M. N. Bramlette and E. Posnjak, "Zeolitic Alteration of Pyroclastics," *Amer. Mineral.*, **18** [4] 167–71 (1933); *Ceram. Abs.*, **12** [8] 308 (1933).

[50] A. L. Crawford and H. O. Cowles, "Fullers' Earth Deposit near Aurora, Utah," *Utah Acad. Sci.*, **9**, 55–60 (1932).

[51] (*a*) U. Hofmann, K. Endell, and D. Wilm, "Kristallstrucktur und Quellung von Montmorillonit," *Z. Krist.*, **86** [5–6] 340–48 (1933); *Ceram. Abs.*, **14** [4] 100 (1935).
(*b*) U. Hofmann and W. Bilke, "Über die Innerkristalline Quellung und das Basenaustauschvermögen des Montmorillonits," *Kolloid-Z.*, **77**, 238–51 (1936).

[52] C. E. Marshall, "Constitution of Clay Minerals," *Science Progress*, **30** [119] 422–33 (January, 1936); *Ceram. Abs.*, **15** [7] 217 (1936).

[53] W. P. Kelley, H. Jenny, and S. M. Brown, "Hydration of Minerals and Soil Colloids in Relation to Crystal Structure," *Soil Sci.*, **41** [4] 259–74 (1936); *Ceram. Abs.*, **15** [9] 285 (1936).

[54] (*a*) W. P. Kelley, W. H. Dore, and S. M. Brown, "Nature of Base-Exchange Material of Bentonite, Soils, and Zeolites, as Revealed by Chemical Investigation and X-Ray Analysis," *Soil Sci.*, **31**, 25–55 (1931).
(*b*) See also footnote reference 34, p. 273.

[55] E. S. Larsen and E. T. Wherry, "Leverrierite from Colorado," *Jour. Wash. Acad. Sci.*, **7**, 208–17 (1917).

[56] E. S. Dana, System of Mineralogy, p. 687, 1909.

[57] Lucien Cayeux, Introduction a l'Étude Petrographique des Roches Sédimentaires, pp. 230–32 (1916); [pl. 9 fig. 5].

at about the same time, had considered leverrierite to be a variety of kaolinite. The clay mineral from Beidell, Colorado, was redescribed in 1925 by Larsen and Wherry[58] under the name

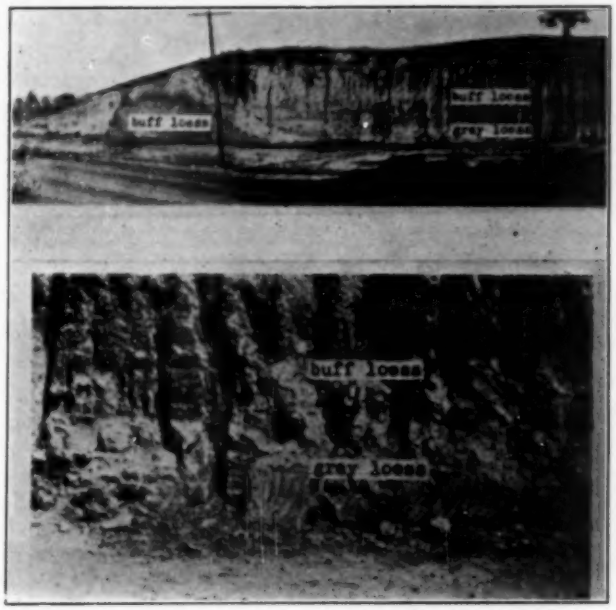

FIG. 11.—Outcrops of loess containing beidellite, near St. Charles, Mo. (photo by R. T. Oefelein).

beidellite (pronounced bei-dell′-ite), and at the same time Ross and Shannon[59] furnished optical and chemical data on the new mineral.

Beidellite is a hydrous aluminum silicate deficient in calcium and magnesium with an Al_2O_3: SiO_2 ratio of about 1:3. Iron may occur in substantial proportions[38] on certain occasions. Beidellite appears to be formed under circumstances similar to those in which montmorillonite is produced. Ross and Shannon described the occurrence of the mineral as an alteration product of volcanic ash in bentonite. Beidellite has also been described as a prominent constituent of loess in southeastern Missouri[60] and also in soils derived from loess in Illinois.[61]

Beidellite exhibits definite differences in properties from montmorillonite. The mineral is by no means comparable to the montmorillonite in technical application. The distribution of beidellite in sediments, however, has not as yet been thoroughly investigated, and it is entirely possible that it may yet prove to be a most widespread mineral.

(3) Nontronite ($(Al, Fe)O_3 \cdot 3SiO_2 \cdot nH_2O$)

Nontronite was originally described in 1897 by Weinschenk[62] as the ferric equivalent of kaolinite. The name was subsequently used for a number of claylike materials. Larsen[63] redescribed the mineral in 1928 and compared it with beidellite. The description was based upon a clay found in a quartz vein carrying metallic ores, located near Woody, Kern County, California. Shortly afterward, it was pointed out by other investigators that nontronite belonged to the montmorillonite group and was related not only to beidellite, but to saponite and montmorillonite as well.[64] More recently, Gruner[65] has confirmed the X-ray studies and has emphasized the structural relationship of nontronite and montmorillonite. It seems clear from these studies that nontronite is related to montmorillonite rather than kaolinite. Gruner has also pointed out that when dehydrated at 575°C nontronite is similar to pyrophyllite in

FIG. 12.—Kaolinite prisms with intergrown hydromica plates (after S. L. Galpin).

structure. Montmorillonite shows a similar structural change when dehydrated, another feature in common between the two minerals.

Nontronite is probably the least common of the minerals of the montmorillonite group and, aside from its structural similarity, shows less justification for inclusion in a group of clay minerals. It represents the member of the group high in

[58] E. S. Larsen and E. T. Wherry, "Beidellite, a New Mineral Name," *Jour. Wash. Acad. Sci.*, **15**, 465–66 (1925); *Ceram. Abs.*, **5** [6] 194 (1926).

[59] C. S. Ross and E. V. Shannon, "Chemical Composition and Optical Properties of Beidellite," *Jour. Wash. Acad. Sci.*, **15**, 467–68 (1925); *Ceram. Abs.*, **5** [3] 100 (1926).

[60] R. T. Oefelein, "Mineralogical Study of Loess near St. Charles, Missouri," *Jour. Sedimentary Petrology*, **4** [1] 36–44 (1934); *Ceram. Abs.*, **13** [8] 220 (1934).

[61] G. E. Ekblaw and R. E. Grim, "Some Geological Relations between the Constitution of Soil Materials and Highway Construction," *Ill. State Geol. Surv. Rept. of Invest.*, No. 42, 16 pp. (1936).

[62] E. Weinschenk, "Beiträge zur Mineralogie Bayerns," *Z. Krist.*, **28**, 150 (1897).

[63] E. S. Larsen and G. Steiger, "Dehydration and Optical Studies of Alunogen, Nontronite, and Griffithite," *Amer. Jour. Sci.*, [5], **15**, 1–19 (1928).

[64] See footnote reference 11, p. 271.

[65] J. W. Gruner, "Structural Relationship of Nontronites and Montmorillonite," *Amer. Mineral.*, **20** [7] 475–83 (1935); *Ceram. Abs.*, **15** [1] 40 (1936).

iron and low in aluminum, calcium, and magnesium. It has been reported as a vein filling by Larsen and Steiger,[63] and has been found as a mineral associated with metalliferous deposits as a later alteration product in a number of places.

Recent studies cast doubt upon the individuality of a number of clay minerals and suggest their identity with nontronite. According to studies by Larsen and Steiger, and by Gruner, the following are probably nontronite: chloropal, pinguite, graminite, mullerite, zamboninite, morencite, hoeferite, faratsihite, and stilpnochloran.

(4) Saponite ($2MgO \cdot 3SiO_2 \cdot nH_2O$)

The portion of the montmorillonite series high in magnesium has been less definitely established than other parts of the group. The work of American investigators up to the present time would indicate that a mineral corresponding to saponite in its chief characteristics is the most commonly observed magnesium-bearing representative. Unfortunately, the earlier descriptions of saponite are considerably in need of review. The origin of the mineral dates back to 1758, according to Dana,[64] but the early descriptions are hard to separate from descriptions of fullers' earth. In 1925, Palache,[65] in his study of some of the minerals of the Keweenawan copper deposits, described saponite as one of the latest hydrothermal minerals to form, occurring in cavities left by excessive solution during replacement of the amygdaloid. In the Ahmeek mine, it was found as a solid filling of replacement vugs surrounding crystals of copper and quartz. The mineral was also found with copper and epidote crystals in open cavities.

The indices of refraction, determined by Larsen, are as follows:

South Kearsarge mine	$\alpha = 1.479$	$\beta = 1.510$	$\gamma = 1.511$
Ahmeek mine	$\alpha = 1.490$	$\beta = 1.525$	$\gamma = 1.527$.

Chemical analyses of both samples indicate substantial proportions of silica, alumina, magnesium, and water. The formula computed by Palache is $Al_2O_3 \cdot 9MgO \cdot 10SiO_2 \cdot 15/16H_2O$.

Through the kindness of Professor Palache, samples of both have been secured for X-ray diffraction patterns. The patterns indicate a material isomorphous with montmorillonite. An impure clay found near Needles, California, has been furnished by Frank Sanborn of the California Bureau of Mines. As reported by Mr. Sanborn, the clay contains about 24% MgO, some alumina, and both silica and water, in amounts corresponding to the percentages common in the montmorillonite group. The clay has been found to yield X-ray diffraction patterns of the same type as Palache's saponite. A clay found in a railroad tunnel in Montreal, Canada, has been described as saponite by Graham.[67] Samples of this clay furnish X-ray diffraction patterns of the same type. Foshag and Woodford[68] have recently described a clay from Hector, California, containing high percentages of magnesium, which yields an X-ray diffraction pattern indicating isomorphism with montmorillonite. The clay is bentonitic in origin and is thought to be somewhat representative of similar clays of high magnesium content found in the Mojave Desert region of California. The interplanar spacings for this clay, however, lie between the spacings of montmorillonite and saponite. A high magnesium-bearing clay from an unknown locality in Utah has been found to yield an X-ray diffraction pattern of the same type.

The results of these studies indicate the existence of a high magnesium-bearing member of the montmorillonite group, isomorphous with montmorillonite. The interplanar spacings for the principal lines shown in a powder photograph are on record,[69] and attention was called to this relationship some time ago.[70]

The nature of magnesium-bearing clay minerals is worthy of further study. Fersman[71] described materials which he called palygorskites[72] in 1908. The group included altered amphiboles and fine, fibrous minerals familiar in asbestos, mountain leather, mountain cork, pilolite, and similar materials, as indicated by recent studies.[73] The

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[64] Charles Palache and Helen Vassar, "Some Minerals of the Keweenawan Copper Deposits," *Amer. Mineral.*, **10**, 412–18 (1925).

[67] R. P. D. Graham, "Saponite from the Canadian Northern Railway Tunnel, Montreal," *Trans. Roy. Soc. Can. Inst.*, [III], **12**, 199–201 (1918).

[68] W. F. Foshag and A. O. Woodford, "Bentonitic Magnesian Clay Mineral from California," *Amer. Mineral.*, **21** [4] 238–44 (1936); *Ceram. Abs.*, **15** [6] 188 (1936).

[69] See footnote reference 44 (*c*), p. 276.

[70] See footnote reference 11 (*a*), p. 271.

[71] A. Fersman, "Über die Palygorskitgruppe," *Bull. acad. imp. sci.* [St. Petersbourg], **2**, 255–74 (1908).

[72] Wolf. von Englehart, "Über Silikatische Tonminerale," *Fortschr. Mineral., Krist., Petrog.*, **21**, 331 (1937).

[73] (*a*) H. Longchambon, "Sur les Propriétés Caracteristiques des Palygorskites," *Compt. rend.*, **203**, 672 (1936).

(*b*) H. Longchambon, "Sur les Caracteristiques des Palygorskites," *ibid.*, **204** [1] 55–58 (1937); *Ceram. Abs.*, **16** [6] 185 (1937).

chief magnesium-bearing mineral of this group apparently is sepiolite, as indicated in recent studies by Longchambon.[74] Sepiolite has a fine, fibrous habit which, in connection with X-ray work, suggests a fibrous structure. Fine fibrous structures do not appear to be characteristic of clay minerals. Saponite or similar high magnesium clays of the montmorillonite group have a characteristic fine micaceous habit suggesting a sheeted structure.

TABLE V
CHEMICAL ANALYSES OF MONTMORILLONITE

	Montmorillonite					
	(1)	(2)	(3)	(4)	(5)	(6)
SiO_2	48.60	51.20	48.24	49.21	53.42	53.88
Al_2O_3	20.03	22.14	22.32	22.61	10.06	11.66
Fe_2O_3	1.25		0.36	0.43	3.40	
FeO					0.18	4.60
MgO	5.24	3.53	6.64	2.13	9.16	8.61
CaO	1.72	3.72	2.04	1.95	1.29	1.56
Na_2O		0.56		0.45	0.02	0.15
K_2O				Trace	0.64	0.39
H_2O-					11.83	8.21
H_2O+	21.52	17.08	20.84	23.71	9.42	9.98
MnO	0.16	0.18			0.02	0.18
TiO_2					0.52	0.44
P_2O_5		1.42			0.12	0.16
Cl					0.02	
CO_2					0.10	
Total	98.52	99.83	100.54	100.49	99.96	99.82

(1) Montmorillon, France.
(2) Branchville, Conn.
(3) Embudo, Mexico. Analyses (1) to (3) from C. S. Ross and Earl Shannon, "Minerals of Bentonite and Related Clays and Their Physical Properties," *Jour. Amer. Ceram. Soc.*, **9**, 77 (1926).
(4) Unterrupsroth, Rhön. F. Heide, *Chem. Erde*, **3**, 91 (1927).
(5) Attapulgus, Ga. P. F. Kerr, "Attapulgus Clay," *Amer. Mineral.*, **22**, 543 (1937).
(6) Tehachapi, Calif. P. F. Kerr and Eugene N. Cameron, "Fullers' Earth of Bentonitic Origin from Tehachapi, California," *ibid.*, **21**, 235 (1936).

TABLE VI
CHEMICAL ANALYSES OF SAPONITE, BEIDELLITE, AND NONTRONITE

	Saponite				Beidellite	Nontronite
	(1)	(2)	(3)	(4)	(5)	(6)
SiO_2	53.68	50.89	46.45	42.78	47.28	47.51
Al_2O_3	0.60	9.40	3.32	6.44	20.27	0.37
Fe_2O_3		2.06	0.42	1.27	8.68	35.17
FeO			0.72			0.00
MgO	25.34	26.52	25.91	24.78	0.70	1.40
CaO	0.52	0.78		2.35	2.75	2.50
Na_2O	3.00			0.75	0.97	0.09
K_2O	0.07			Trace	Trace	0.06
H_2O-	7.28	11.06	14.48	13.96	19.72	7.16
H_2O+	8.24		8.13	7.90		5.90
MnO				0.12		
Cl	0.31					
Li_2O	1.12					
Total	100.16	100.71	99.43	100.35	100.37	100.16

Saponite
(1) Hector, California. W. L. Foshag and A. O. Woodford, *Amer. Mineral.*, **21**, 241 (1936).
(2) Svardsjo, Sweden. Ak. H. Svanberg, Stockholm, 153, 1840.
(3) Montreal, Canada. R. P. D. Graham, *Trans. Roy. Soc. Can.*, [III], **12**, 199 (1918).
(4) South Kearsarge Mine, Mich. C. Palache and H. Vassar, *Amer. Mineral.*, **10**, 414 (1925).
Beidellite (5) Beidell, Colo. C. S. Ross and E. V. Shannon, *Jour. Wash. Acad. Sci.*, **15**, 467 (1925).
Nontronite (6) Woody, Calif. E. S. Larsen and G. Steiger, *Amer. Jour. Sci.*, [5], **15**, 1 (1928).

V. Alkali-Bearing Clay Mineral Group

The alkali-bearing clay minerals form a group of fairly widespread occurrence. Unfortunately, the minerals of this group occur so rarely in mineralogically pure specimens that precise information is difficult to obtain. The most generally used names associated with this group are hydromica and metabentonite.

(1) Hydromica

Workers with clay minerals (Selle,[75] Hickling,[76] Somers,[77] Galpin,[78] and others[79]) some time ago recognized a micalike material formed as an intermediate product during the alteration of feldspathic minerals to kaolinite. Denison, Fry, and Gile,[80] a number of years ago investigated the alteration of muscovite and biotite in soil. It was their observation that the alteration is progressive, various stages being found even in the same soil. Nagelschmidt[81] and Endell[82] have shown that structurally this material is slightly different from muscovite and may be distinguished. X-ray patterns leading to a similar

[74] (*a*) H. Longchambon and G. Migeon, "Sur les Sepiolites," *Compt. rend.*, **203** [7] 431–33 (1936); *Ceram. Abs.*, **16** [1] 41 (1937).
(*b*) H. Longchambon, "Sur Certaines Caracteristiques de la Sepiolite d'Ampandrandava et la Formule des Sepiolites," *Bull. soc. franç. minéral.*, **60**, 232–76 (1937).

[75] V. Selle, "Über Verwitterung und Kaolinbildung Hallescher Quarzporphyre," *Z. Naturwissenschaften*, **79**, 321–23 (1907).
[76] G. Hickling, "China Clay: Its Origin and Nature," *Trans. Inst. Mining Engrs.* [London], **36**, 10–33 (1908).
[77] R. E. Somers, "Microscopic Study of Clays," *U. S. Geol. Surv. Bull.*, No. 708, pp. 292–305 (1922).
[78] S. L. Galpin, "Studies of Flint Clays and Their Associates," *Trans. Amer. Ceram. Soc.*, **14**, 301–46 (1912).
[79] (*a*) A. Brammall, "Reconstitution Processes in Shales, Slates, and Phyllites," *Mineralog. Mag.*, **19**, 211–24 (1921).
(*b*) W. S. Bayley, "Kaolin in North Carolina, with a Brief Note on Hydromica," *Econ. Geol.*, **15**, 236–46 (1920), *Ceram. Abs.*, **1** [4] 102 (1922).
See also footnote reference 1, p. 268.
[80] I. A. Denison, W. H. Fry, and P. L. Gile, "Alteration of Muscovite and Biotite in the Soil," *U. S. Dept. Agric. Tech. Bull.*, No. 128, pp. 1–32 (1929).
[81] G. Nagelschmidt, "X-Ray Investigations of the Clays; III, Differentiation of Micas by X-Ray Powder Photographs," *Z. Krist.*, **97**, 514–21 (1937).
[82] K. Endell, U. Hofmann, and E. Maegdefrau, "Über die Natur des Tonanteils in Rohstoffen der Deutschen Zement-Industrie," *Zement*, **24** [40] 625–33 (1935); *Ceram. Abs.*, **15** [11] 346 (1936).

conclusion were taken by the writer in connection with studies of Illinois clay and shale.[83] Ross has

FIG. 13.—The probable center of volcanic activity in Middle Ordovician time as shown by G. Marshall Kay; ash from volcanoes drifted over the great inland sea to give rise to the metabentonite now found in Ordovician sediments. (G. M. Kay, *Bull. Geol. Soc. Amer.*, **46**, 241 (1935).)

pointed out that this product differs somewhat both optically and chemically from muscovite.[84] Maegdefrau and Hofmann[85] have studied the micaceous constituents of clay and point out differences between muscovite and the micaceous constituent of certain clays. Recently, the name "illite" has been proposed by Grim[86] for material from the Pennsylvanian shales of Illinois, corresponding to the hydromica of Galpin, Somers, and others. The material has been frequently referred to in the literature as sericitelike, micalike hydromica, or as "glimmerton" by European authors.[87]

Microscopic studies indicate that the material is an intermediate alteration product produced in shale or clay of sedimentary origin. It seems possible that it may yet be shown to correspond with one of the forms of mica previously described, although as yet the correlation has not been established. It is a substantial constituent of sedimentary clays and an intermediate product in the formation of soil.

(2) Metabentonite

The term *metabentonite* was proposed by Ross[88] to describe the compact, massive shale or even slatelike, alkali-bearing clays found in the Ordovician in the central and eastern parts of the United States.[89] Because this material has been produced by the alteration of volcanic ash, it is desired to emphasize its bentonitic origin. On the other hand, the persistent and substantial alkali content and difference in mineralogical character necessitate some modification of the

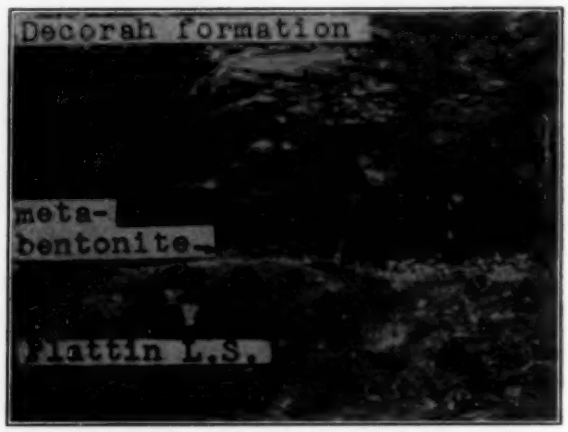

FIG. 14.—Metabentonite layer in Ordovician strata of Missouri (photo by V. T. Allen).

word bentonite. The term "metabentonite" has been applied as a rock name,[88] although as yet no attempt has been made to identify and classify

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[83] (*a*) R. E. Grim, "Petrology of the Pennsylvanian Shales and Non-calcareous Underclays Associated with Illinois Coals," *Bull. Amer. Ceram. Soc.*, **14** [3] 113–19; [4] 129–34; [5] 170–76 (1935).
(*b*) R. H. Bray, R. E. Grim, and P. F. Kerr, "Application of Clay Mineral Technique to Illinois Clay and Shale," *Bull. Geol. Soc. Amer.*, **46** [12] 1909–26 (1935); *Ceram. Abs.*, **15** [5] 163 (1936).

[84] See footnote reference 1, p. 268.

[85] E. Maegdefrau and U. Hofmann, "Glimmerärtige Mineralien als Tonsubstanzes," *Z. Krist.*, **98**, 31–59 (1937).

[86] R. E. Grim, R. H. Bray, and W. F. Bradley, "Mica in Argillaceous Sediments," *Amer. Mineral.*, **22** [7] 813–29 (1937); *Ceram. Abs.*, **17** [4] 157 (1938).

[87] (*a*) F. K. Schlünz, "Eine Microskopische, Röntgenographische, und Chemische Untersuchung des Liastons von Dobbertin," *Chem. Erde*, **10**, 116–25 (1936); *Ceram. Abs.*, **15** [5] 165 (1936).
(*b*) C. W. Correns and F. K. Schlünz, *Z. Pflanzenkrankh. Pflanzenschutz*, **44**, 316 (1936).
(*c*) See footnote 25 (*b*), p. 272.
See also footnote reference 85.

[88] C. S. Ross, "Altered Paleozoic Volcanic Materials and Their Recognition," *Bull. Amer. Assn. Petroleum Geol.*, **12**, 143–64 (1927).

[89] V. T. Allen, "Ordovician Altered Volcanic Material in Iowa, Wisconsin, and Missouri," *Jour. Geol.*, **40**, 259–69 (1932).

satisfactorily the clay mineral constituent. These clays are not of any considerable economic importance, but form a most interesting group from the standpoint of occurrence. There is an extended bibliography on the stratigraphic importance of this clay. Layers of metabentonite occur within the comparatively narrow limits of the Middle Ordovician throughout the Appalachian district, in Missouri,[89] Iowa, Wisconsin, and Canada. It has been suggested that a group of active volcanoes existed somewhere within the continent of eastern North America in Ordovician time. The ash distributed by these volcanoes is now the metabentonite in the Ordovician sediments throughout the wide area mentioned.

The chemical and physical differences between Ordovician metabentonite and the Tertiary-Cretaceous bentonite suggest the possibility that montmorillonite is not a sufficiently resistant mineral to withstand the processes to which Paleozoic rocks have been subjected.

TABLE VII

CHEMICAL ANALYSIS OF METABENTONITE

	Metabentonite
SiO_2	53.12
Al_2O_3	18.72
Fe_2O_3	1.12
CaO	1.40
MgO	6.92
K_2O	5.72
Na_2O	Trace
H_2O	12.04
F	No data
Total	99.04

Ordovician metabentonite from High Bridge, Ky.; collected by Charles Butts; purified by C. S. Ross; analyzed by E. V. Shannon, *Jour. Amer. Ceram. Soc.*, 9 [2] 77–96, p. 92 (1926).

VI. Internal Structures of the Clay Minerals

The same principles which have enabled recent investigators to assign internal structures to other silicate minerals have been applied to the clay minerals. The minute crystals of which the minerals are composed may be assumed to be made up of groups of ions, positive and negative in character. Surrounding each positive ion is a group of negative ions and *vice versa*. The attractive forces between ions bind the structures together. The force of attraction of an individual ion terminates abruptly at a spherical surface which centers at the nucleus. The radii of these spheres are within narrow limits alike for the same ions, even in different substances. The ionic radii for the common elements found in the clay minerals are recorded by Bragg[90] as follows:

O	1.32 Å	Ca	1.06 Å
OH	1.32	Fe	0.67 (trivalent)
Si	0.39	Fe	0.83 (divalent)
Al	0.57	Na	0.98
Mg	0.78	K	1.33

Two common clusters of ions are linked to produce a series of fundamental rings which form

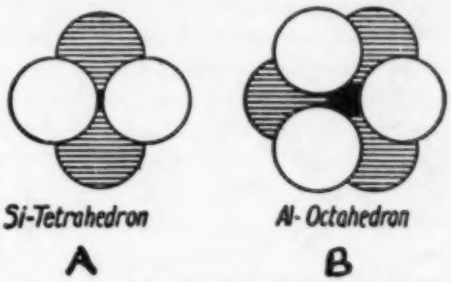

FIG. 15.—(*A*) tetrahedral arrangement of O ions about a Si center; (*B*) octahedral arrangement of O and OH ions about an Al center.

the skeleton of the various structures proposed for the clay minerals.[91] In one cluster, four oxygen ions are symmetrically arranged around one silicon

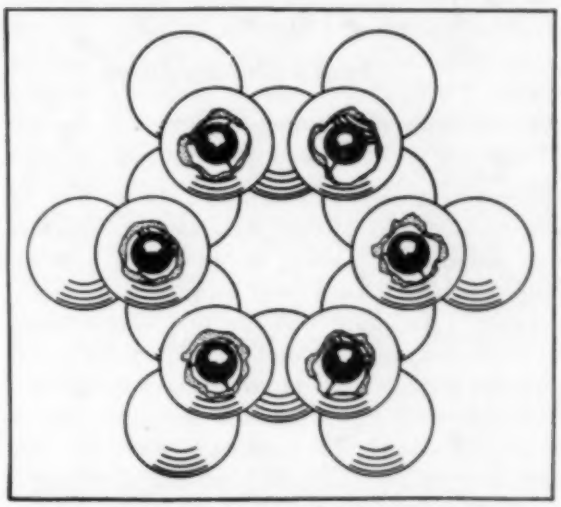

FIG. 16.—Diagram of the Si–O hexagonal ring.

[90] W. L. Bragg, Atomic Structure of Minerals. Cornell Univ. Press, Ithaca, New York, xiii + 292 pp., 1937; *Ceram. Abs.*, **17** [6] 231 (1938).

[91] (*a*) Linus Pauling, "Principles Determining Structure of Complex Ionic Crystals," *Jour. Amer. Chem. Soc.*, **51**, 1010–26 (1929).

(*b*) Linus Pauling, "Structure of the Chlorites," *Proc. Nat. Acad. Sci. U. S.*, **16**, 578–82 (1930).

(*c*) Linus Pauling, "Structure of Micas and Related Minerals," *ibid.*, **16**, 123–29 (1930).

ion. The oxygen ions occupy the corners of a tetrahedron and the silicon ion occupies the center. In another cluster, aluminum or magnesium ions occupy the center of an octahedron, surrounded by O or OH ions. These two common clusters may be interlocking and form sheetlike layers of rings. The ions of the structure are frequently conceived as subject to substitution by ions of other elements.

The structure of muscovite mica was investigated by Mauguin,[92] prior to the study of clay

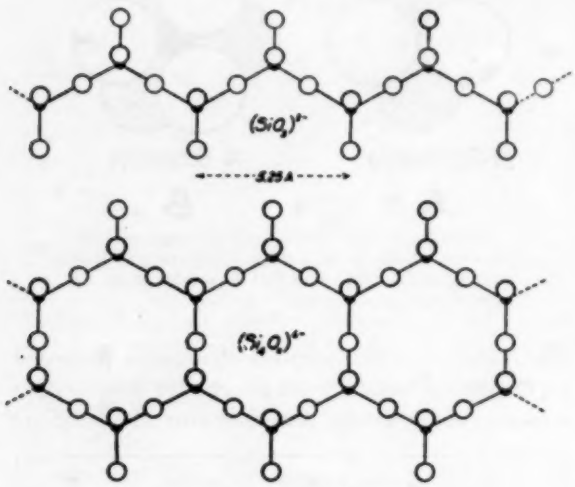

FIG. 17.—Diagram of Si–O chains (after W. L. Bragg).

mineral structures, and furnished the pattern for structural studies of clay minerals. A structure was proposed consisting of groups of ions arranged in sheets, each layer forming a hexagonal network. Kaolinite was the first clay mineral to be worked out structurally.[93] The mineral was pictured as made up of interconnected tetrahedral and octahedral groups forming individual layers, each with a hexagonal pattern. Since the hexagonal layers are offset, the resultant symmetry is no longer hexagonal. The structures of the various clay minerals worked out since have yielded various modifications, but have adhered to the same principle of sheeted layers.

[92] (*a*) C. Mauguin, "Étude du Mica Muscovite au Moyen des Rayons, X," *Compt. rend.*, **185**, 288–91 (1927). (*b*) C. Mauguin, "Réseaux Polaires et Diagrammes de Diffraction des Rayons, X," *Bull. soc. franç. minéral.*, **49**, 5–32 (1926).

[93] See footnote 91 (*b*).

Kaolinite,[94] dickite,[95] nacrite,[96] and montmorillonite[97] have been studied structurally. The skeletons of the structures assigned to the minerals just mentioned as a result of X-ray study have been agreed upon by different workers. As indicated recently by Bragg,[90] however, it is probable that the X-ray analysis of the clay minerals has only commenced.

Marshall[98] has discussed the colloidal properties of clays as related to crystal structure. Structures of the sheet-layer type are considered, after Pauling. The structures are most instructive as they apply to halloysite and montmorillonite.

Gruner[94] confirmed Pauling's work on kaolinite, made more extensive measurements, and considered the ionic arrangements in greater detail. Gruner pointed out that in kaolinite adjoining layers of two sheets consisting of OH radicals and O ions, respectively, are not completely balanced. He suggested that the resultant strain might also explain why kaolinite crystals never grow beyond their minute dimensions. He also suggested that anauxite is kaolinite in which Si occupies Al positions with a covalence of 6. In order to compensate the electrostatic valence, O takes the place of OH, which accounts for a decrease of H_2O in analyses of anauxite.

Dickite provides about the best X-ray data for structural studies among the clay minerals on account of somewhat larger and better-defined crystals. Some crystals are satisfactory for X-ray methods dependent upon individual crystals. The layers of ions in dickite are practically identical with those in kaolinite, but differ in the directions and magnitudes of the shifts of the sheets of ions over each other. The better crystallization of dickite may be explained by the more symmetrical positions of OH ions in

[94] J. W. Gruner, "Crystal Structure of Kaolinite," *Z. Krist.*, **83**, 75–88 (1932).
See also footnote reference 13, p. 271.

[95] (*a*) J. W. Gruner, "Crystal Structure of Dickite," *Z. Krist.*, **83**, 394–404 (1932).
(*b*) C. J. Ksanda and T. F. W. Barth, "Note on Structure of Dickite and Other Clay Minerals," *Amer. Mineral.*, **20** [9] 631–37 (1935); *Ceram. Abs.*, **15** [1] 40 (1936).

[96] J. W. Gruner, "Crystal Structure of Nacrite and a Comparison of Certain Optical Properties of the Kaolin Group with Its Structures," *Z. Krist.*, **85** [5–6] 345–54 (1933); *Ceram. Abs.*, **12** [10–11] 395 (1933).

[97] E. Maegdefrau and U. Hofmann, "Kristallstruktur des Montmorillonits," *Z. Krist.*, **98**, 299–323 (1937).

[98] C. E. Marshall, "Colloidal Properties of Clays as Related to Their Crystal Structure," *Jour. Phys. Chem.*, **41**, 935–42 (1937).

the structure with respect to O ions in the hexagonal groups. The structure proposed by Gruner for dickite has been restudied by Ksanda and Barth[95(b)] and also by Hendricks.[99] Both fail to confirm certain features, but agree concerning the general pattern.

Nacrite is said by Gruner[96] to be built of the same kind of layers as dickite; however, in nacrite each layer is rotated 180° in its own plane with respect to its nearest neighbors.

Structural studies of the other clay minerals are less definite. Maegdefrau and Hofmann[97] have suggested a structure for montmorillonite made up of sheeted layers following the scheme applied in the interpretation of other clay mineral structures.

TABLE VIII

GRUNER'S STRUCTURAL DATA FOR CLAY MINERALS

	Mineral		
	Kaolinite and anauxite	Dickite	Nacrite
System	Monoclinic	Monoclinic	Monoclinic
Space group	C_s^4	C_s^4	C_s^4
Molecules in unit cell	4	4	8
Formula	$(OH)_4Al_2Si_2O_5$	$(OH)_4Al_2Si_2O_5$	$(OH)_4Al_2Si_2O_5$
Theoretical density	2.609	2.589	2.581
Unit cell Å			
a_o	5.14	5.14	5.16 ± 0.02
b_o	8.90	8.94	8.93 ± 0.02
c_o	14.51	14.42	28.66 ± 0.04
β	100°12′–101° 30′	96°50′	91°43′ ± 15′

VII. Base Exchange

The term "hydrous aluminum silicate" is so frequently used in connection with clay minerals that it may be forgotten that important clays often contain substantial amounts of other elements. Calcium, magnesium, iron, and the alkali elements, sodium and potassium, are at times more than minor constituents of clay minerals. Members of the montmorillonite group as found in bentonite contain calcium and magnesium as essential constituents. In a few bentonites, magnesium has been found to be a more abundant constituent than aluminum. Fullers' earth contains substantial quantities of magnesium. Clays formed by alteration of Paleozoic volcanic ash have been found to contain considerable amounts of potassium and some sodium.

In 1876, Lemberg[100] discovered that the alkali-silicate mineral, leucite, could be changed to the calcium silicate mineral, analcite, by base exchange. Potassium in the leucite could be replaced by calcium to form analcite or *vice versa*. The same principle may be applied to the clay minerals, but in some clays the substitutions are made with much greater facility than in others. It has been observed that sodium, calcium, and potassium form the most active bases from the standpoint of base exchange. Magnesium, on the other hand, is not so easily replaceable. The explanation of this difference has been attributed to the corresponding ionic radii of these elements. Sodium, calcium, and potassium have large ionic radii, while the ionic radius of magnesium is considerably smaller. It is thought possible, for this reason, to exchange the larger elements of more or less the same size for each other with less strain on an atomic structure.

Kelley,[101] Marshall,[102] van der Meulen,[103] Edelman,[104] and others have discussed the relationship between the crystal structure of clay minerals and base exchange. In the common structural interpretations of clay minerals, aluminum ions may occur surrounded either by four or six negative ions, consisting either of O or OH. In such cases, the coördination number is either 4 or 6. In some silicate structures, the Al in tetrahedra may require one additional charge to balance the surrounding four negative oxygen charges. Potassium may do this in orthoclase, biotite, and muscovite. Sodium does the same in albite, analcite, and natrolite. Substitutions of the same sort may account for base exchange in clay minerals. The theory of replacement on the broken edges of a crystal lattice advanced by Hofmann and his associates is not supported by Kelley. He believes exchange occurs within the lattice.

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[99] See footnote reference 28, p. 272.

[100] J. Lemberg, "Über Silikatumwandlungen," *Z. deut. geol. Ges.*, **28**, 519–621 (1876).

[101] W. P. Kelley and Hans Jenny, "Relation of Crystal Structure to Base Exchange and Its Bearing on Base Exchange in Soils," *Soil Sci.*, **41**, 376–82 (1936).

[102] (*a*) C. E. Marshall, "Importance of Lattice Structure of Clays for the Study of Soils," *Jour. Soc. Chem. Ind. (Trans.)*, **54**, 393–98 (1935); *Ceram. Abs.*, **15** [4] 131 (1936).

(*b*) C. E. Marshall, "Layer Lattices and the Base Exchange Clays," *Z. Krist.*, **91**, 433–49 (1935).

[103] J. B. van der Meulen, "Relation between the Phenomenon of Cation Exchange with Silica-Alumina Complexes and Their Crystal Structure," *Rec. trav. chim.*, **54** 107–13 (1935); *Ceram. Abs.*, **14** [6] 152 (1935).

[104] C. H. Edelman, "Relations between the Crystal Structure of Minerals and Their Base Exchange Capacity," *Trans. Third Internatl. Congress of Soil Sci.*, **111**, 97–99 (1936).

Base exchange experiments have shown that fine grinding over long periods will materially increase the base exchange capacity of some clays.[101] Even minerals not easily subject to base exchange capacity may show some base exchange capacity after fine grinding. On the other hand, fine grinding has failed to improve the base exchange capacity of some minerals and has produced only moderate increase in the capacity of some clays.

It is the conclusion of Kelley[101] that potassium, sodium, and calcium in clays are essentially replaceable. Magnesium is only replaceable in small amount by the alkalis or NH_4, at least not when OH ions constitute parts of the octahedra. Magnesium, on the other hand, can readily replace other replaceable cations. It would appear, according to Kelley, that base exchange capacity may be explained either on the basis of accessibility in the lattice structure or on the basis of the attractive force by which the bases are held to the lattice.

The experiments of Noll[105] may be of interest in this connection. In the synthesis of montmorillonite at 300°C (optimum temperature of formation), it was found that with calcium, potassium, or sodium new components (analcite, for example) would form as the ratio of bases to Al_2O_3 approached 1:1. With magnesium, only montmorillonite would form, even when the ratio was 2:1.

Soil workers have used base exchange to describe the reaction which certain insoluble constituents of soils undergo when in contact with a salt solution. For descriptive purposes, the cations from the salt solution may be said to replace the bases from the soil. Soil workers have shown that these reactions are particularly applicable to clay minerals. Among the clay minerals, the montmorillonite group and halloysite, according to Edelman,[104] are subject to strong base exchange capacity. Kaolinite, on the other hand, has low base exchange capacity.

VIII. Water Content of Clay Minerals

Progress was made in the study of the water content of clay minerals before the more recent optical and X-ray methods were developed. A number of workers had investigated the dehydration of kaolin. With the separation of kaolinite, dickite, and nacrite,[1] it became possible to study the dehydration curves of the three minerals more effectively. It was demonstrated that large losses of water occur within a limited temperature range, no comparable losses occurring either at higher temperatures or at lower temperatures.

TABLE IX

COMPARATIVE BASE EXCHANGE CAPACITY

(After Kelley and Jenny)

Mineral	Grain size	Milli-equivalent per 100 g.	Time ground (hr.)	Milli-equivalent per 100 g.
Stilbite	Moderately ground	304.5		
"Permutite"	Unground	225.0	48	225.0
Scolecite	Moderately ground	209.3		
Bentonite	1 u.	126.0	72	238.0
Beidellite	1 u.	50.0	48	200.0
Muscovite	100-mesh	10.0	72	76.0
Kaolinite	" "	8.0	7 days	100.5
Orthoclase	" "	5.0	120	91.5
Pyrophyllite	" "	4.0	7 days	150.5
Biotite	" "	3.0	72	72.5
Oligoclase	" "	2.6	72	27.0
Anorthite	" "	2.0	96	33.0
Labradorite	" "	2.0	96	37.0
Albite	" "	1.0	72	70.0

The large loss of water occurred in kaolinite and anauxite near 450° to 525°C; the large loss in dickite near 540°C; and the principal loss in nacrite between 525° and 650°C. Insley and Ewell[106] have pointed out that when kaolinite is heated there is a broad endothermic effect near 550°C, and water-vapor, amorphous alumina, and amorphous silica result. There is an exothermic effect at 950°C and β-alumina is formed. The same writers[107] have succeeded in the synthetic preparation of dickite, kaolinite, beidellite, and nontronite by heating various compounds in a pressure bomb. The temperatures at which the minerals were formed were as follows: kaolinite, 310°C, dickite, 350°C, and 365°C, beidellite, 350° and 390°C, and nontronite, 350°C.

Studies of halloysite at a later date indicated large water losses at temperatures slightly below those most characteristic of kaolinite; consider-

[105] W. Noll, "Synthese von Montmorilloniten," *Chem. Erde*, **10** [2] 129–54 (1936); *Ceram. Abs.*, **16** [3] 99 (1937).

[106] H. Insley and R. H. Ewell, "Thermal Behavior of Kaolin Minerals," *Jour. Research Nat. Bur. Stand.*, **14** [5] 615–28 (1935); R.P. 792; *Ceram. Abs.*, **14** [8] 201 (1935).

[107] H. Insley and R. H. Ewell, "Hydrothermal Synthesis of Kaolinite, Dickite, Beidellite, and Nontronite," *Jour. Research Nat. Bur. Stand.*, **15** [2] 173–86 (1935); R.P. 819; *Ceram. Abs.*, **14** [11] 290 (1935).

able amounts of water, however, were lost at comparatively low temperatures. Mehmel[108] arrived at the conclusion that, on the basis of water content and structure, two types of halloysite existed.

Montmorillonite furnishes the most interesting behavior of water among the clay minerals. It ordinarily contains the largest amount of water, sometimes as much as 25%. Samples in the laboratory vary in water content with the humidity of the atmosphere. Dehydration curves fail to show large losses within the narrow limits observed for the kaolin group of minerals. Gradual losses up to about 450°C are characteristic in the ordinary curves. Kelley[101] recently has made a more careful study of the dehydration of montmorillonite under carefully controlled conditions. The more recent curves indicate two general types of water-loss. Up to 180°C, large losses of water occur which are ascribed to adsorbed water. At higher temperatures, around 450°C, large losses occur which are ascribed to crystal lattice water.

Hofmann and co-workers have been interested in the effect of water content on the crystal lattice of montmorillonite. It appears that expansion in the lattice occurs as more and more water fills the interstices between the sheetlike layers in the crystal lattice. Following this idea recently, Grim and his associates[109] have suggested a series of montmorillonite structures corresponding to different amounts of water. Five discrete hydrates are thought to exist as follows:

"Pyrophyllite"	2 H_2O
"P"– 6 H_2O	8 H_2O
"P"–12 H_2O	14 H_2O
"P"–18 H_2O	20 H_2O
"P"–24 H_2O	26 H_2O

Evidence for these conclusions exists in the variation in spacing of one important plane in the lattice as measured by X-rays. Unfortunately, the X-ray measurements of montmorillonite are not as satisfactory as X-ray measurements of other clay minerals. Structures, as pointed out by Nagelschmidt, are also difficult to establish and to some extent uncertain.[110] The observations, however, are most constructive and point toward a much better understanding of the behavior of water in montmorillonite.

Recently, Mehmel[108] has investigated the relationship between indices of refraction and water content in montmorillonite, halloysite, and kaolinite from 0° to 700°C. Curves of indices of refraction plotted against hydration curves show a tendency to parallelism in certain portions and striking differences in others. Longchambon[111] has devised equipment to allow measurement of the rapidity of dehydration which may prove of considerable value. The combined study of dehydration, indices of refraction, X-ray diffraction, base exchange, and crystal structure as applied to

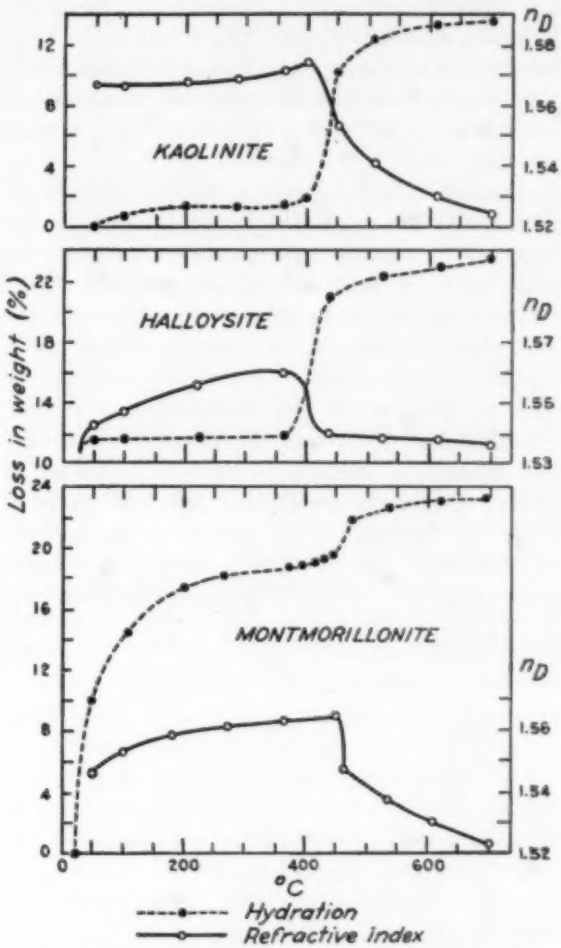

FIG. 18.—Comparative curves of indices of refraction and hydration of kaolinite, halloysite, and montmorillonite, from 50° to 700°C (after Mehmel).

[108] See footnote reference 27, p. 272.
[109] See footnote reference 33, p. 273.
[110] G. Nagelschmidt, "Lattice Shrinkage and Structure of Montmorillonite," *Z. Krist.*, **93** [6] 481–87 (1936); *Ceram. Abs.*, **15** [8] 258 (1936).
[111] H. Longchambon, "Courbes des Dehydration des Minéraux," *Bull. soc. franç. minéral.*, **59**, 145–61 (1936).

this mineral in the last few years has yielded information which may prove of far-reaching importance in its applications.

IX. Conclusion

It is possible to review, only in the most general terms, the progress of clay mineral research in the past decade. Furthermore, predictions concerning the future application of recent discoveries are always uncertain. Ceramic technologists, however, should find much of interest in the careful studies of the nature of clay minerals. Observations of the behavior of water in clays and variations in physical properties, in some cases without change in chemical composition, are significant. The fundamental studies of the montmorillonite group should be of interest to the industry in refining mineral and vegetable oils. Clay mica, metabentonite, and bentonite have considerable value in the interpretation of the geological significance of certain strata. The nature and origin of clay have always been a problem of interest to the mineralogist. Colloid chemists may find recent observations concerning the relation of surface to internal structure of value. Engineers are finding detailed studies of clays of increasing importance. Agricultural chemists have not only found recent clay mineral research of interest, but in a number of cases they have taken up the work themselves and have made important contributions. In addition to these broad applications, many of a minor nature have been found. Recent discoveries have already demonstrated their value, and as time goes on, further applications of these discoveries will be found.

In any review of research progress, a considerable amount of interest is attached to those workers who have been most active. Throughout the recent clay mineral investigations, Endell, Hofmann, Edelman, Noll, Nagelschmidt, Maegdefrau, Marshall, Longchambon, von Englehart, Lapparent, Correns, and Mehmel have been among those most active abroad. In this country, Ries, Kelley, Bayley, Insley, Grim, Woodford, Hendricks, Foshag, Larsen, Wherry, Shannon, Gruner, and Allen have been actively associated with clay mineral studies. Worthy of special consideration, however, has been the work of Clarence S. Ross, of the U. S. Geological Survey. Not only in his published work, which has been well recognized, but in many informal contributions, all too frequently forgotten in the published descriptions of others, has he pushed the investigation of the mineralogy of clay in recent years.

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X-RAY DIFFRACTION STUDY OF SODA-BORIC OXIDE GLASS*

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Abstract

X-ray diffraction patterns have been made of three samples of soda-boric oxide glass of the following molal compositions: 0.114 Na_2O, 0.225 Na_2O, and 0.333 Na_2O. The patterns were made in an evacuated camera, using MoK α radiation monochromated by reflection from rock salt. Radial distribution curves for the three compositions were obtained by Fourier analysis. The first peak of the distribution curves is due to the boron-oxygen separation. The distances are 1.37, 1.42, and 1.48A. From the peak areas, the number of oxygens about a boron is found to be 3.2, 3.7, and 3.9. The continuous change, both in interatomic distance and number of surrounding oxygens, indicates that the borons are partly in triangular and partly in tetrahedral coördination, the fraction in the latter increasing with increase of soda. Six oxygens about each sodium at 2.4A and from five to six oxygens about each oxygen at 2.4A are consistent with the distribution curves. The results can be interpreted in terms of a random network picture of vitreous soda-boric oxide, in which the borons are bonded either to three or four oxygens and the sodium atoms are randomly distributed in holes in the boron-oxygen network. Maxima and minima in the physical properties of glasses containing boric oxide and soda are explained in terms of the ability of the boron atom to change to tetrahedral coördination when some oxide such as Na_2O is present to supply the necessary extra oxygen.

I. Introduction

(1) Experimental

Three samples of soda-boric oxide glass having the following compositions were examined:

Table I

Composition of Samples

	Weight fraction		Molal fraction	
(1)	0.103 Na_2O	0.897 B_2O_3	0.114 Na_2O	0.886 B_2O_3
(2)	0.206 "	0.794 "	0.225 "	0.775 "
(3)	0.308 "	0.692 "	0.333 "	0.667 "

The samples were made by melting C.P. $Na_2B_4O_7 \cdot 10H_2O$ and C.P. H_3BO_3 in a platinum crucible until a clear liquid free of bubbles was obtained. The samples were analyzed for both Na_2O and B_2O_3. For the X-ray work, rods about one millimeter in diameter were drawn from the melt. These rods were clear and glassy in appearance, and there was no observable change in them after they had been in the evacuated X-ray camera for several days. When not in use, the samples were stored in vacuum over phosphoric anhydride. There was no observable difference between the pattern of a sample freshly prepared and one which had been thus stored. Even if there were a thin layer of altered material on the surface, the scattering from the surface layer would be negligible compared to the X-ray scattering from the body of the sample.

The diffraction patterns shown in Fig. 1 were made in an evacuated camera of radius 4.40 centimeters, using MoKα radiation monochromated by reflection from a rock-salt crystal. Exposures ranged from 6 to 20 hours. Values of intensity were computed from microphotometer traces of the patterns and were plotted against $\frac{\sin\theta}{\lambda}$, where θ is half the scattering angle and λ, the wave-length of the MoK α line. These curves are shown in Fig. 2, together with the intensity curve for boric oxide.[1] The change in the curves with increasing soda content is perfectly continuous. The second and third peaks of the B_2O_3 curve appear in all four curves, practically unchanged in position and height. The first peak of the B_2O_3 curve is progressively flattened and at the diborate composition has spread out into two peaks.

(2) Results

From a Fourier analysis of the intensity curves of Fig. 2, a set of distribution curves for the respec-

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† Glass Research Fellow. This paper constitutes the third report of work done with the assistance of the Glass Research Fellowship sponsored by eight American glass manufacturers.

[1] B. E. Warren, H. Krutter, and O. Morningstar, "Fourier Analysis of X-Ray Patterns of Vitreous SiO_2 and B_2O_3," *Jour. Amer. Ceram. Soc.*, **19** [7] 202–206 (1936).

tive glasses is obtained. The theory and application of the Fourier method to a binary glass has been discussed in a previous paper.[2] The resulting distribution curves are shown in Fig. 3.

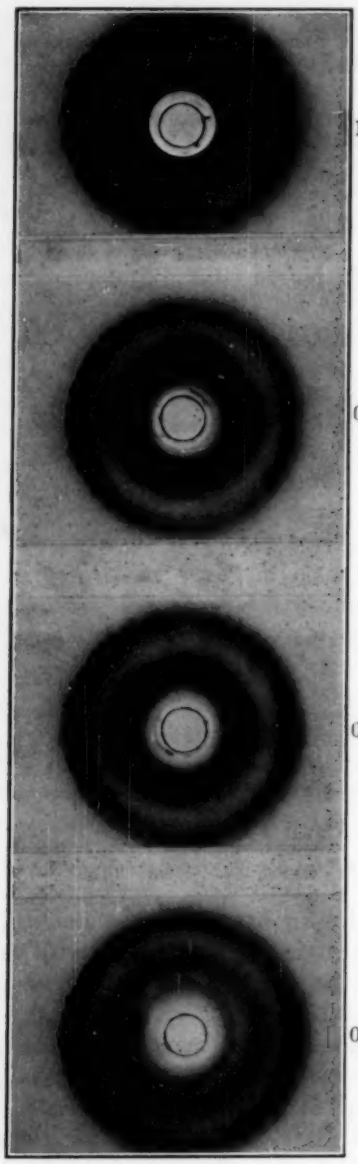


FIG. 1.—X-ray diffraction patterns of soda-boric oxide glass.

Each of these curves is really a composite of three separate distribution curves, *viz.*, (1) the distribution of atoms about any boron, (2) the distribution about any oxygen, and (3) the distribution about any sodium atom. The dotted portion of these curves has no physical significance, owing to errors inherent in the method.

The first peak occurs at values of 1.39, 1.37, 1.42, and 1.48A, starting with B_2O_3 and going progressively to higher soda content. These distances are interpreted as the average boron-oxygen separation in the glass. From the X-ray analysis of crystalline borates,[3] it is found that

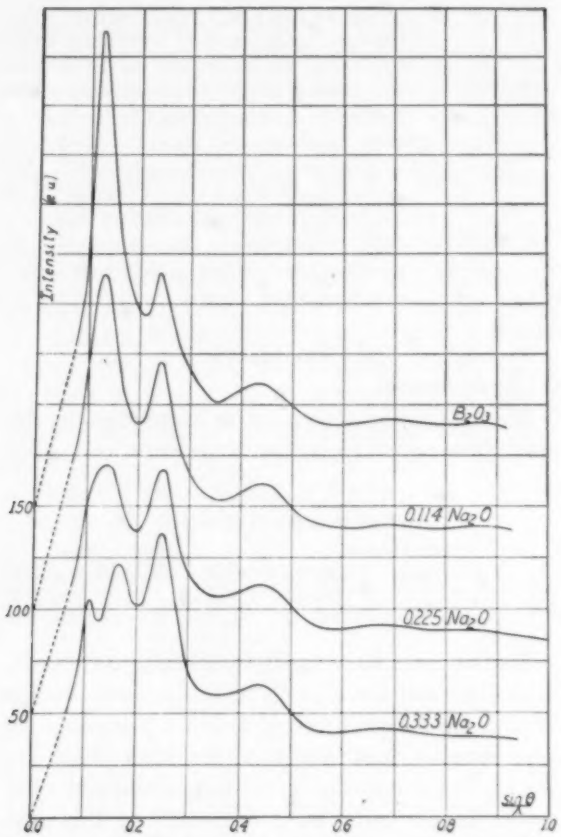


FIG. 2.—X-ray intensity curves for soda-boric oxide glass.

the boron atom is usually bonded to three oxygens, but may occasionally be bonded to four oxygens. In the usual triangular coördination, the average B-O distance in crystalline borates is 1.36A. In tetrahedral coördination, the distance is greater, and, in the compound $KH_2(H_3O)_2B_5O_{10}$, the tetrahedral B-O distance is found to be 1.53A. The

[2] B. E. Warren and J. Biscoe, "Fourier Analysis of X-Ray Patterns of Soda-Silica Glass," *Jour. Amer. Ceram. Soc.*, **21** [7] 259–65 (1938).

[3] (*a*) W. H. Zachariasen and G. E. Ziegler, "Crystal Structure of Calcium Metaborate, CaB_2O_4," *Z. Krist.*, **83** [5–6] 354–61 (1932); *Ceram. Abs.*, **12** [3] 124 (1933).
(*b*) "Crystal Lattice of Boric Acid (BO_2H_3)," *Z. Krist.*, **88** [2] 150–61 (1934); *Ceram. Abs.*, **13** [9] 242 (1934).
(*c*) "Crystal Structure of $KH_2(H_3O)_2B_5O_{10}$," *Z. Krist.*, **98**, 266 (1937).

progressive increase in the average boron-oxygen distance obtained from the first peak would seem to indicate that with increase of soda more and more of the borons are tetrahedrally rather than triangularly coördinated.

From the area of the first peak, the average number of oxygens about a boron may be calculated. The values obtained are given in Table II.

TABLE II
BORON-OXYGEN DISTANCES AND BORON COÖRDINATION

	B-O distance	No. of oxygens
B_2O_3	1.39A	3.1
0.114 Na_2O, 0.886 B_2O_3	1.37A	3.2
.225 Na_2O, .775 B_2O_3	1.42A	3.7
.333 Na_2O, .667 B_2O_3	1.48A	3.9

The peak areas also indicate a transition from triangular to tetrahedral coördination with increase of soda. While the accuracy of neither the peak position nor the average number of surrounding oxygens is as high as would be desirable, the fact that both quantities show the same trend makes it highly probable that the effect is real.

The next peak occurs at 2.4A and has an approximately constant position throughout the series. From crystalline structure studies, the sodium atoms would be expected to be surrounded by about six oxygens at a distance of 2.35A. The results obtained from soda-silica glass[2] are in good agreement with these values. In the case of B_2O_3 with its triangular coördination, the nearest oxygen-oxygen distance should be

$$1.36\sqrt{3} = 2.4\text{A},$$

and there should be four neighbors at this distance. For tetrahedral coördination, the distance from one oxygen to another on the same tetrahedron will be

$$1.53\sqrt{\frac{8}{3}} = 2.5\text{A}.$$

If it is assumed that each oxygen is bonded to two borons, then, depending on how the tetrahedra and triangles are linked to each other, each oxygen should have between 4 and 6 oxygen neighbors at an average distance of about 2.45A. If the area under the peak at 2.4A is measured and the area due to six oxygens about a sodium is subtracted, the remaining area corresponds to between 5 and 6 oxygens about an oxygen. The second peak can therefore be interpreted as due to about 6 oxygens around each sodium at a distance of 2.4A, and between 5 and 6 oxygens at a distance of about 2.45A from each oxygen. In the light of the soda-silica glass results and the studies of crystalline borates and silicates, these results are reasonable.

The next distance that is at all definite is the boron-boron distance at 2.7 to 3.1A. The calculated area of this peak is, however, too small to allow it to show on the distribution curve. Beyond the second peak at 2.4A, there are no other well-resolved peaks. Distances become so indefinite that it is not possible to correlate any of the other peaks with particular interatomic separations.

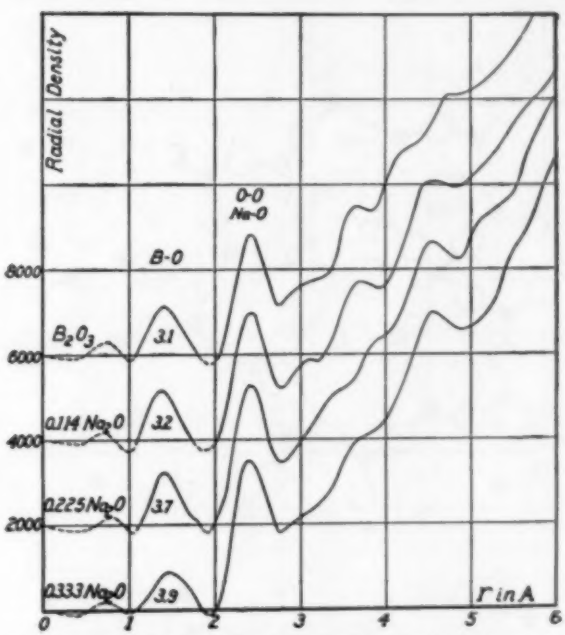


FIG. 3.—Radial distribution curves for soda-boric oxide glass obtained by Fourier analysis.

II. Structure of Soda-Boric Oxide Glass

The distribution curves of Fig. 3 lead to a simple picture of a soda-boric oxide glass. Figure 4 represents schematically, in two dimensions, the structure of a glass of low soda content. Each boron is bonded either to 3 or 4 oxygens, the fraction in tetrahedral coördination increasing with increase in soda content. Figure 4 is only schematic in that the tetrahedral groups are shown with all 4 oxygens in the same plane. For low soda content each oxygen is bonded between 2 borons. The boron and oxygen atoms form a random network, in which the boron coördination is partly triangular and partly tetrahedral. The nature of this network is therefore intermediate

between the tetrahedral network of vitreous silica and the triangular network of vitreous boric oxide. It is an open-type network, with holes between the oxygens of the right size to accommodate a sodium ion. The sodium ions are arranged at random in these network holes, with each sodium surrounded on the average by about 6 oxygens.

The arrangement of the sodium ions in the network holes either in a soda-boric oxide or a soda-silica glass is completely analogous to the scheme of structure in a feldspar. In a feldspar crystal, the silicon, aluminum, and oxygen atoms form an open tetrahedral network, and the alkali and

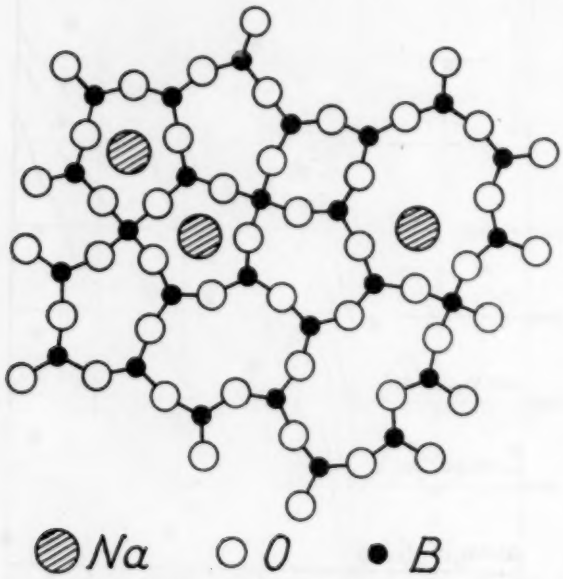


FIG. 4.—Schematic representation in two dimensions of the structure of a soda-boric oxide glass of low soda content.

alkaline earth atoms are arranged in the holes in this network. It should perhaps be emphasized that the oxides do not exist as molecules in the glass. The sodium ions, Na^+, are situated in the holes in the boron-oxygen network.

The existence of discrete B_2O_3 molecules in the glass is definitely ruled out. The distribution curves require each boron to be bonded at least to 3 oxygens, with a B-O distance about 1.4A and O-O about 2.4A. It is impossible to build up a discrete unit, B_2O_3, which satisfies these conditions without putting the two borons unreasonably close together. The nonexistence of B_2O_3 molecules in the glass is not at all surprising inasmuch as the X-ray studies of crystalline borates give no indication of the existence of a B_2O_3 molecule.

The X-ray results do not uniquely prove that soda-boric oxide glass is noncrystalline. The diffuseness of the X-ray scattering curves, however, shows that any assumed crystallites must be so small that the term "crystalline" has no definite meaning. The X-ray results give no evidence for picturing glassy soda-boric oxide as a mixture of boric oxide and some soda-boric oxide compound.

III. The Boric Oxide Anomaly

Probably the most interesting result of this study is the indication that with increasing soda content, more and more of the boron atoms go over from triangular to tetrahedral coördination. In the following discussion it will be shown that maxima and minima in the physical properties of glasses containing boric oxide and soda can be explained by the ability of the boron atom to change from triangular to tetrahedral coördination when an oxide, such as Na_2O, is present to supply the necessary extra oxygen.

NOTE: The authors are indebted to W. Weyl for calling their attention to the anomalous properties of glasses containing soda and boric oxide.

In the composition B_2O_3, the oxygen-boron ratio is 1.50, and if each oxygen is to be shared by not more than two borons, it follows that each boron can not be bonded to more than three oxygens. Each oxygen being bonded to not more than two of the principal glass-forming cations is the necessary condition for sufficient flexibility to allow a glass structure to exist.[4] If a small amount of soda is added to the B_2O_3, the oxygen-boron ratio becomes greater than 1.50. With each oxygen shared between 2 borons, there is now enough oxygen for some of the borons to be bonded to 4 oxygens. As more soda is added, more and more borons change over to tetrahedral coördination. For all of the borons to go into tetrahedral coordination would require an oxygen-boron ratio of 2.00, corresponding to the metaborate composition, $Na_2O \cdot B_2O_3$. Evidence to be discussed later indicates, however, that beyond about 16% Na_2O, the tendency for the borons to change over to tetrahedral coördination begins to fall off, and the transition is no longer complete. This

[4] W. H. Zachariasen, "Atomic Arrangement in Glass," *Jour. Amer. Chem. Soc.*, **54** [10] 3841–51 (1932); *Ceram. Abs.*, **12** [4] 145 (1933).

is not surprising, because triangular coördination is the normal coördination of the boron atom, and only special conditions will force it into tetrahedral coördination. With further increase in soda, the additional oxygens are no longer completely taken up by borons changing over from triangular to tetrahedral coördination. Some oxygens will be bonded only to one boron. To represent the structure at this stage, Fig. 4 must be modified so that some of the oxygens are bonded only to one boron. The number of these single-bonded oxygens will increase with increase in soda content.

The changes in coördination in a soda-boric oxide glass can be followed very simply on the thermal-expansion curve[5] shown in Fig. 5(*c*). In B_2O_3, each boron is bonded to the rest of the structure in three directions in a plane. The bonding of the plane triangular group, BO_3, to the rest of the structure is essentially two dimensional and therefore weak. Without changing appreciably the B-O distance, thermal motion of the atoms can readily increase distances perpendicular to the BO_3 group and produce the large coefficient of expansion of B_2O_3.

With the addition of a few per cent of soda, part of the borons change over to tetrahedral coördination. The BO_4 groups are bonded to the rest of the structure in four directions, and the structure is therefore tied together in three dimensions rather than only in two. This will produce a marked increase in the strength and tightness of the structure. The forces of attraction between the sodium ions and the surrounding oxygens will also contribute to the increased strength of the structure. The rapid decrease in the coefficient of thermal expansion from 0 to 16% Na_2O is interpreted as due to the progressive change of the borons to tetrahedral coördination.

With further addition of soda, the tendency to change to tetrahedral coördination becomes smaller, the excess oxygens are no longer completely taken up by borons changing to tetrahedral coördination, and some of the oxygens are left, bonded only to one boron. This produces breaks in the boron-oxygen network and a decrease in the strength of the structure. The greater the number of single-bonded oxygens, the looser the structure. The rising thermal expansion, greater than 16% for soda, is interpreted as due to the loosening of the structure by increase in the number of single bonded oxygens.

The measured density[5] of soda-boric oxide glass is shown in Fig. 5(*b*). There is a general increase, which falls off noticeably at about 17%. By idealizing this picture considerably, it is possible to calculate a theoretical density curve for low soda content.

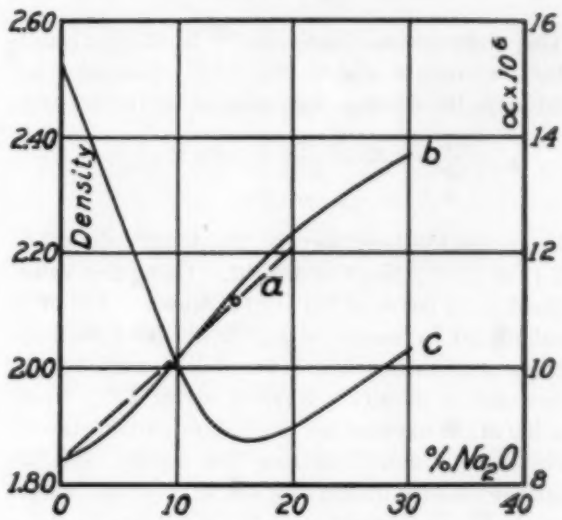


FIG. 5.—Thermal expansion coefficient and density of a soda-boric oxide glass: (*a*) calculated density for low soda content; (*b*) measured density; and (*c*) measured coefficient of thermal expansion.

Consider the molal composition, $Na_2O \cdot 5B_2O_3$, written in the form $(Na_2O \cdot B_2O_3) \cdot 4B_2O_3$. In the component, $Na_2B_2O_4$, the oxygen-boron ratio is 2.00, and all of the borons are assumed to be in tetrahedral coördination with the sodium ions in the network holes. The arrangement of boron and oxygen can be assumed to be the same as the arrangement of silicon and oxygen in vitreous silica. If vitreous silica is used with the oxygens undisturbed, each silicon is replaced by a boron, and for each boron one sodium ion is introduced into a network hole, a hypothetical $Na_2O \cdot B_2O_3$ glass would result. In making this change, there would be a shrinkage in volume, owing to the fact

NOTE: Splitting the composition into the two components, $Na_2O \cdot B_2O_3$ and $4B_2O_3$, is wholly arbitrary and done solely for convenience in calculating the density. There is no intention to imply that the glass is a mixture of the two compounds, $Na_2B_2O_4$ and B_2O_3.

[5] (*a*) E. J. Gooding and W. E. S. Turner, "Study of Series of Glasses Containing Sodium Oxide, Boric Oxide, and Silica," *Jour. Soc. Glass Tech.*, **18** [69] 32–66 (1934); *Ceram. Abs.*, **13** [9] 234 (1934)

(*b*) S. R. Scholes, Modern Glass Practice, p. 268. Industrial Publications, Inc., Chicago, Ill., 1935; *Ceram. Abs.*, **15** [4] 120 (1936).

that the Si-O distance is 1.62A and the tetrahedral B-O distance[6] is about 1.50A. The density of this hypothetical glass, $Na_2B_2O_4$, can be calculated in terms of the density of vitreous silica, 2.20, the ratio of the weights $Na_2O \cdot B_2O_3$ to Si_2O_4, and the ratio of the volumes.

NOTE: It is hypothetical for two reasons, (1) a glass can not be formed at the metaborate composition and (2) it has been assumed that all the borons in $Na_2B_2O_4$ are in tetrahedral coördination. For the calculation of the density of $Na_2O \cdot 5B_2O_3$, this amounts to assuming one-fifth of the borons to be in tetrahedral coördination.

$$\rho = 2.20 \times \frac{131.8}{120.2} \times \left(\frac{1.62}{1.50}\right)^3 = 3.04.$$

The composition $Na_2O \cdot 5B_2O_3$ is 32.1% $Na_2O \cdot B_2O_3$ by weight and 67.9% B_2O_3. Assuming additivity, the density is calculated by the relation,

$$\frac{1}{\rho} = 0.321 \times \frac{1}{3.04} + 0.679 \times \frac{1}{1.84}$$

$$\rho = 2.11.$$

From this idealized picture, the density should be 2.11 at 15.1% Na_2O by weight. Using this value, the density curve of Fig. 5(*a*) is drawn. Although calculated by means of highly idealized assumptions, it gives the right order of magnitude for the increase in density. Beyond about 17% Na_2O, some of the oxygens are bonded only to one boron, the density should increase less rapidly, and the considerations underlying curve 5(*a*) no longer apply.

The same considerations allow a ready understanding of the fact that the addition of soda produces exactly opposite effects if added to boric oxide or if added to silica. As described before, when a few per cent of soda is added to boric oxide, part of the borons are changed over to tetrahedral coördination and are tied to the rest of the structure by four bonds rather than three. This increases the strength of the glass, or, in other words, produces a harder glass. On the other hand, when soda is added to silica the opposite effect occurs. Silicon does not show the ability of boron to change its coördination number. The coördination number of silicon is always four, each silicon tetrahedrally surrounded by four oxygens. With the addition of soda, the oxygen-silicon ratio becomes greater than 2.00. This requires that part of the oxygens be bonded only to one silicon, thus producing breaks in the silicon-oxygen network. Because the strength of the structure is mainly in the silicon-oxygen network, the more of these breaks, the looser or weaker the structure. With increase in soda content, there is an increase in the number of single bonded oxygens and, as a result, a progressively softer glass.

In soda-boric oxide-silica glasses, many physical properties show maxima or minima as a function of composition.[7] Figure 6 shows the density for a series of compositions having a constant soda content of 20%. A pronounced maximum occurs at about 18% B_2O_3. For convenience in calculation, consider the composition by weight 20.0 Na_2O, 22.5 B_2O_3, 57.5 SiO_2, which on a molal basis is $Na_2O \cdot B_2O_3 \cdot 3SiO_2$. Writing this in the form $Na_2(B_2Si_3)O_{10}$, it is seen that the oxygen to principal cation ratio is 2.00, and it is possible for both the silicon and boron atoms to be in tetrahedral coördination. Comparison with the silica composition written in the form Si_5O_{10} gives the glass structure by replacing two-fifths of the silicons by boron atoms and by introducing for each boron one sodium ion into the holes in

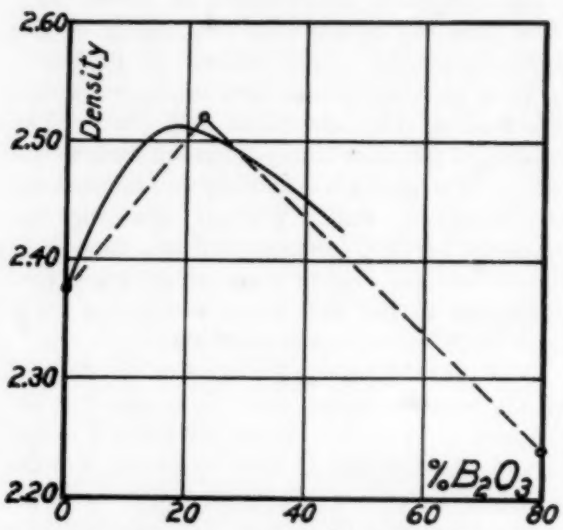


FIG. 6.—Density of a soda-boric oxide-silica glass containing 20% Na_2O; *full curve*, measured density; *dotted curve*, calculated density from idealized structure.

[6] Weighted average of three values obtained from $KH_2(H_3O)_2B_5O_{10}$, BPO_4, and $BAsO_4$.
W. H. Zachariasen, "Crystal Structure of $KH_2(H_3O)_2B_5O_{10}$," *Z. Krist.*, **98**, 270 (1937).

[7] (*a*) S. English and W. E. S. Turner, "Physical Properties of Boric Oxide Containing Glasses and Their Bearing on the General Problem of the Constitution of Glass," *Jour. Soc. Glass Tech.*, **7** [26] 155 (1923); *Ceram. Abs.*, **3** [2] 36 (1924).
(*b*) A. Cousen and W. E. S. Turner, "Study of the Glasses Boric Oxide-Silica," *Jour. Soc. Glass Tech.*, **12**, 169 (1928).

the network. The density of the resulting glass is calculated in terms of the density of silica, 2.20, the ratio of the weights, $Na_2B_2Si_3O_{10}$ to Si_5O_{10}, and the shrinkage in volume due to replacing two-fifths of the silicons by borons. Since Si-O = 1.62A and B-O = 1.50A, the shrinkage factor will be

$$\frac{2}{5}\times\left(\frac{1.62}{1.50}\right)^3+\frac{3}{5}\times 1.00 = 1.104$$

$$\rho = 2.20 \times \frac{312.1}{300.5} \times 1.104 = 2.52.$$

The dotted curve of Fig. 6 is obtained from the measured density of 20% Na_2O, 80% SiO_2; the measured density of 20% Na_2O, 80% B_2O_3; and the calculated density for the composition, 22.5% B_2O_3. The interpretation of this curve is as follows: At 0% B_2O_3, the soda-silica glass has a density of 2.37, which contains an appreciable number of single-bonded oxygens. A small amount of B_2O_3 is now added. Part of the single-bonded oxygens are changed to double-bonded to allow all of the added borons to go into tetrahedral coördination. As more B_2O_3 is added, more of the single-bonded oxygens are used up, and the density rises. At the composition 22.5% B_2O_3, all of the single-bonded oxygens are used up (the oxygen to silicon-boron ratio is just 2.00). With further addition of B_2O_3, it is no longer possible for the boron to change to tetrahedral coördination because no extra oxygen bonds are available. The additional boron atoms remain in triangular coördination, and because this involves bonding to the rest of the structure in three directions only rather than four, the structure becomes steadily looser and the density decreases.

The maximum is determined by the condition that as many as possible of the borons have gone into tetrahedral coördination and all single-bonded oxygens are used up. This condition occurs when the oxygen to silicon-boron ratio is just 2.00. For any small soda content, the maximum or minimum in the physical properties of a soda-boric oxide-silica glass should occur at a composition for which the B_2O_3 to Na_2O ratio is roughly unity. The experimental data which are available are in fairly good agreement with this requirement.

It should be pointed out that the anomalous behavior can not be ascribed to the oxide B_2O_3 alone. The anomalies occur only when B_2O_3 is present with some other oxide, such as Na_2O, which can supply the additional oxygen necessary for the boron to change to tetrahedral coördination. In a boric oxide-silica glass, there is never more than enough oxygen to allow each silicon to bond to four oxygens and each boron to three oxygens. There is no chance for the boron to go into tetrahedral coördination, and no maxima or minima appear in the boric oxide-silica glasses.

George Eastman Laboratory of Physics
Massachusetts Institute of Technology
Cambridge, Massachusetts

AMERICAN CERAMIC SOCIETY NEW ORLEANS MEETING WAS A FLOP

This was the verbal declaration made in the Society's executive office on Saturday, July 2, by one who was unable to attend that Meeting.

His positive opinion that the Meeting was a flop was based on (1) his pre-Meeting thoughts that no successful ceramic meeting could be held in New Orleans, (2) materials salesmen told him that it was a flop, and (3) he had not seen that the Society had reported it as being a success. He had not read the trade paper reports of the large attendance and profitable and well-attended meetings. He had not read the account published in the April issue of *The Bulletin*.

YES SIR! THAT NEW ORLEANS MEETING WAS A FLOP

It was a flop from an expected low to a surprisingly high attendance and that, too, in spite of the "recession."

It was a flop from an anticipated poor program to one that was unusual in value and interest.

It was a flop from poorly attended to well-attended meeting sessions.

To the disappointment of some disgruntled few, there was a flop from private room entertainment to delegates going on their own to places of interest.

That Meeting was a flop from high to relatively low expense; from, "Where do we go next?" to "How soon will we again meet in New Orleans?"; from some disgruntled ones to a unanimous agreement that the New Orleans Meeting was most enjoyable and profitable.

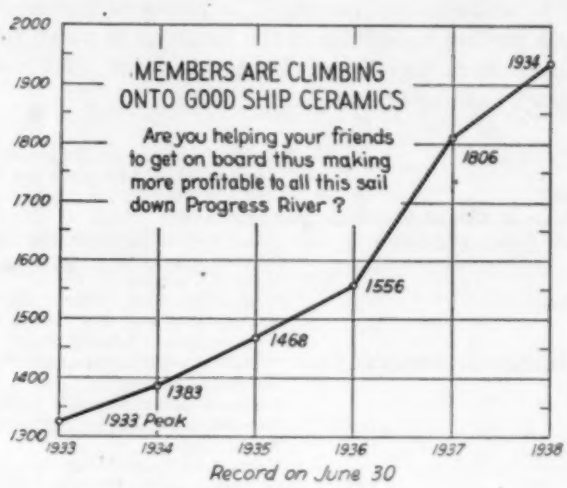
May future meetings "flop" in all the particulars that characterized the Fortieth Annual Meeting in New Orleans last March.

DIVISIONS ANNOUNCE AUTUMN MEETING SCHEDULES

Division	Place	Date
White Wares and Materials and Equipment	Bedford Springs Hotel, Bedford, Pa.	September 15–17
Glass	Chamberlin Hotel, Old Point Comfort, Va.	September 9–12
Refractories	Bedford Springs Hotel, Bedford, Pa.	September 2–3
Art	Dearborn Inn, Dearborn, Mich.	October 24–25
Art	Ceramic Exhibit, Syracuse Museum	October 27–November 21
Enamel	P.E.I. Forum, Univ. of Illinois	October 12–14

All Divisions Forty-First Annual Meeting	Stevens Hotel, Chicago, Ill.	April 16–22, 1939
General Autumn Meeting	San Francisco, Calif.	September, 1939

SUCCEED WITH THE SUCCESSFUL



MORE CERAMIC SAILORS JOIN CREW OF "GOOD SHIP CERAMICS"—SAILING PROGRESS RIVER

- Note that rise in Membership Curve!
- It is bent slightly under the weight of the worst economic recession ever experienced in the U.S.A. but still it is rising toward the 1929 peak.
- Except where there are devastating wars, the economic welfare of the industrial world, other than the U.S.A., is in good shape and is improving. Why not in the U.S.A.?
- Ceramic schools, associations, and exhibits in many nations are increasing in number, size, and activities. Industrial concerns are liberally supporting these schools, associations, and exhibits because they realize that their companies can prosper only by these organized means of research, education, and promotion. Should not U. S. ceramic manufacturers realize the benefit of financial investment in these organized means of technical advancement?
- Why are there only 210 ceramic corporations supporting this Society by payment of the minimum fee of $25.00? Is it because this privilege has not been personally presented?
- The Board has approved payment of dues on an allocated time basis; *i.e.*, persons and corporations may join in mid-calendar year and pay only the portion of the year's dues represented by the months remaining. Those who join in July need pay only one-half of the annual dues, *i.e.*, $6.25 Personal and $12.50 Corporation, and may purchase the publications for the first six months at 20% discount.

Forward-going aggressive ceramists succeed only by continually studying, not narrowly, but broadly, the current problems in all ceramic fields.

Coming Together + Keeping Together + Working Together Adds up to Individual and Collective Success

WANTED: ABSTRACTERS FOR THESE JOURNALS

The following journals contain material of interest to readers of *Ceramic Abstracts*. An abstracter for any of these journals should (1) have the journal available in his personal library or in a public, laboratory, or school library to which he has access, (2) be prepared to submit the abstracts regularly each month, and (3) possess a reading knowledge of the language in which the publication is printed. Address all requests for assignments to the office of *Ceramic Abstracts*, 2525 North High St., Columbus, Ohio. Journals will be assigned to those first requesting them.

Agricultura [Louvain]
American Journal of Pharmacy
American Review of Tuberculosis
American Soil Survey Assn., Report of Annual Meeting
Anales de la Sociedad Española de Física y Química
Annales agronomiques
Annual Review of Biochemistry
Arch. für Hygiene und Bakteriologie
Architecture
Architecture & Building
Archives de Minéralogie de la Société des sciences et des lettres de Varsovie
Art et Decoration
Belg. Netherl. Klei Ind.
Bibliografia Italiana
Building Economy
Bull. Acad. Roy. Belgique
Bulletin de l'Institut du Pin
Bulletin de la Section Scientifique de l'Académie Roumaine
Bulletin de la Société Chimique du Royaume de Yougoslavie
Bull. Soc. Geologique France
Canadian Public Health Jour.
Cemento
Ceramica
Clay Products News
Compt. Rend. Inst. Geol. Roumanie
Corriere dei Ceramisti
Deutsche Goldschmiede-Zeitung
Deutsche Wollen Gewerbe
Documentation Scientifique
Electricité
Farben-Zeitung
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Fette und Seifen
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Ingénieur Chimiste
Ingegnere
Ingenieria [Mexico]
Ingeniøren
Inst. Mekhanicheskoi Obrabotki Poleznuikh Isokopaemuikh Mekhanobr
Jahrb. Geol. Bundesanstalt
Jernkontorets Annaler
Journal of Hygiene
Journal de Physique et Radium
Jour. Roman Studies
Jour. Roy. Inst. British Architects
Keramic Tile Journal
Khimicheskoe Mashinostroenie
Klei
Klinische Wochenschrift
Koks i Khimiya
Kolloidnyi Zhurnal
Legkie Metally
Lerindustrien
Magyar Chemiai Folyóirat
Mathematischer und naturwissenschaftlicher Anzeiger der ungarischen Akademie der Wissenschaften
Med. du Travail
Metall & Erz
Metallwaren-Industrie und Galvano-Technik
Mineral'noe Syr'e
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Mon. Phys. Phys.-Chem. Glass (Moscow)
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Naturwissenschaften
Natuurwetenschappelijk Tijdschrift
Nauchnye Zapiski po Sakharnoĭ Promyshlennosti
Nitrocellulose
Nova Acta Leopoldina
Oesterreichische Chemiker-Zeitung
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Paint, Oil & Chemical Review
Periodico di Mineralogia (Rome)
Photographic Abstracts
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Proceedings Royal Academy of Sciences of Amsterdam
Proceedings of the Iowa Academy of Science
Pub. Nat. Bur. Econ. Research, Inc.
Razvedka Nedr
Redkie Metally
Reichsarb.-Bl.
Reports of the Imperial Fuel Research Institute, Japan
Reports of the Imperial Industrial Research Institute, Osaka, Japan
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Trans. State Institute of Applied Chemistry [U.S.S.R.]
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Verhandel. Akad. Wetenschappen Amsterdam, Afdeel Natuurkunde
Wärme
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Zeitschrift für Praktische Geologie
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The bold-face number following the journal name is the volume; the issue number is in brackets, followed by the page numbers, then the year in parentheses.

August, 1938
17—8

Abrasives

Abrasive disks with a ceramic bond. A. P. Bendryshev and A. D. Shapiro. *Tsentral. Nauch. Issledovatel. Inst. Bumazh. Prom. Materialy*, No. 1, pp. 117–36 (1936); abstracted in *Chem. Zentr.*, **1938, i,** 3096.—The characteristics, composition, structure, and manufacture of American abrasives are discussed. The manufacture of abrasives from a mixture of clay and Portland cement with corundum and "resol" rosins as bond is dealt with. M.V.C.

Adhesives for polishing wheels. Henry R. Power. *Metal Cleaning & Finishing*, **10** [1] 51–54 (1938).—Cellulose nitrate and cellulose acetate are not only strong adhesives for certain purposes but are also insoluble in water. Silicate of soda, in the more viscous grades, acts as bond for certain types of grinding wheels, requiring less time for manufacture than vitrified wheels. Large grinding wheels are more easily made by the silicate process because firing temperatures required are lower than with vitrified wheels. Animal glue is used as the adhesive for grits finer than No. 100. Silicate of soda, on standing for some time in a film exposed to air, becomes less soluble in water and is therefore more difficult to remove. Dried animal-glue films are always comparatively easy to redissolve in water; thus, used polishing wheel heads are easily replaced. While silicate of soda is available in several degrees of viscosity, these must originate at the point of manufacture. Since it supports no form of vegetable or animal life, it retains its almost odorless condition indefinitely. Dry ground glue requires no particular care in storage except prevention against extreme dryness. After making up with water, glue requires attention to prevent spoilage by bacteria, evaporation, etc. Animal glue is applied hot and then cooled to form a jelly with a cured water content of 10 to 15%; below this it weakens the film strength. Silicate of soda is applied at room temperature and the brittle film which it forms wears down with the abrasive, exposing new surfaces of abrasive. E.J.V.

Automatic polishing and buffing of copper, nickel silver, and stainless steel. C. Garner. *Monthly Rev. Amer. Electroplaters' Soc.*, **25** [2] 96–101 (1938); *Bull. Brit. Non-Ferrous Metals Research Assn.*, No. 108, p. 112 (1938).—G. discusses automatic and semiautomatic machines, preparation of polishing wheels, selection and testing of buffing materials, and special precautions for avoiding contamination of stainless steel surfaces.

Effect of polishing on corrosion resistance. William M. Phillips. *Monthly Rev. Amer. Electroplaters' Soc.*, **24,** 27–33 (Jan., 1937); *Metals & Alloys*, **9** [4] MA236 (1938).—Salt-spray tests on cold-rolled auto-body sheet steel, polished in different ways and plated, indicated that the use of highly polished sheet with a minimum amount of grit polishing is preferable. No failure was evident after 3 days with 0.001 in. deposits of Cu, Ni, or both.

Grinding and polishing as modern surface treatment. K. Walter. *Chem. App.*, **25** [9] 141–44 (1938). M.H.

Grits for grinding. Philip H. Smith. *Sci. Amer.*, **158,** 266–69 (1938).—S. reviews the recent development of abrasives. W.D.F.

Manufacture of emery cloth and sandpaper. M. Singer and E. Liebermann. *Seifensieder-Ztg.*, **64,** 482–84, 503–504 (1937).—This is a treatise on the abrasive, the cloth, and the glue. E.W.S.

Manufacture of grinding wheels. G. Lanorville. *Nature* [Paris], No. 3024, pp. 276–80 (1938).—L. discusses

different kinds of grinding wheels, their constitution, manufacturing processes, firing and finishing of the products, characteristics, properties, and uses. R.W.D.

Nuglu—abrasive bond. ANON. *Metal Cleaning & Finishing*, **10** [2] 148 (1938).—Nuglu, manufactured by J. J. Siefen Co., Detroit, Mich., is a true abrasive bond used to set up all kinds of polishing wheels, belts, or disks with all sizes of abrasives. It is free from harmful impurities, contains neither silica nor asbestos, does not thicken upon standing (being used without cooking or heating), forms an insulation for the wheel, belt, or disk, and is stable to 2000°F. E.J.V.

Portable electric surfacing. FRED H. SCHELL. *Metal Cleaning & Finishing*, **10** [2] 130–38 (1938).—A portable electric surfacer is a machine weighing up to about 40 lb., powered by an electric motor (usually the Universal type), and capable of being made into a surfacer of any desired type by interchanging the tools on the work spindle. Two general types of tools are being made, the right angle, generally referred to as a sander, and the extended spindle type which is commonly known as a portable grinder. With either type a variety of tools can be attached to the work spindle to adapt it to the work in question. E.J.V.

PATENTS

Abrading apparatus. H. W. DEMPSEY. U. S. 2,119,738, June 7, 1938 (March 8, 1937). In a device, a rotary body has a working pad and a backing pad, a cushion on the working face of the working pad, and an abrading element upon the cushion and having attached means anchored between the pads.

Abrasive article and cement. D. E. WEBSTER (Norton Co.). Can. 373,835, May 17, 1938 (Sept. 8, 1936). G.M.H.

Abrasive articles and manufacture. NORTON GRINDING WHEEL CO., LTD. Brit. 483,777, May 11, 1938 (April 16, 1936).

Abrasive assembly. J. E. LOEWY. U. S. 2,118,409, May 24, 1938 (March 20, 1937). An abrasive assembly comprises an abrasive wheel, a backing plate separable therefrom provided with spaced openings, and threaded members adapted to secure the wheel and plate together.

Abrasive bodies and manufacture. NORTON GRINDING WHEEL CO., LTD. Brit. 483,778, May 11, 1938 (May 28, 1936).

Agglomerated granular material. COMPAGNIE DES MEULES NORTON (SOC. ANON.). Fr. 817,978, Sept. 15, 1937; *Chem. Abs.*, **32**, 2308 (1938).—Grains such as oxides of Al, Zr, and Ti, carbon materials such as diamond, and carbides of Si, B, W, Ta, and Ti are ceramically agglomerated by mixing the grains with a ceramic binder which softens below 1100°, *e.g.*, an alkali metal borosilicate, molding, and heating to below 1100° for a short time. To form a binder, borax, boric acid, and SiO_2 are mixed to form a glass containing B_2O_3 more than 15, SiO_2 less than 70, K_2O and Na_2O less than 10, CaO, MgO, and BaO 0 to 5, and Al_2O_3 0 to 10%, which melts below 1050°. A plastic clay is added to form a moldable mass.

Blade-sharpening machine. W. W. HARTMAN. U. S. 2,118,197, May 24, 1938 (Nov. 19, 1937).

Buffing compositions. C. V. GLENNING (E. I. du Pont de Nemours & Co.). U. S. 2,119,159, May 31, 1938 (Jan. 21, 1937). A buffing composition contains an abrasive, a waxy binder, petrolatum, and an organic amine salt of a sulfated higher aliphatic alcohol.

Cutter grinder. J. B. ARMITAGE (Kearney & Trecker Corp.). U. S. 2,118,912, May 31, 1938 (Oct. 29, 1934). F. W. CURTIS (Kearney & Trecker Corp.). U. S. 2,118,967, May 31, 1938 (Oct. 17, 1934).

Cylinder surfacing tool. H. W. ZIMMERMAN (Automotive Maintenance Machinery Co.). U. S. 2,118,720, May 24, 1938 (March 28, 1936).

Drill grinding tool. W. H. FISCHER. U. S. 2,119,741, June 7, 1938 (March 24, 1937).

Finishing and polishing machine. C. J. LIPPOLD (J. M. Nash Co.). U. S. 2,119,954, June 7, 1938 (July 29, 1935).

Grinding apparatus with eccentrically driven grindstone. OSWALD LINDNER. Ger. 653,173, Nov. 16, 1937; Cl. 50*b*. 2.10; *Chem. Abs.*, **32**, 1526 (1938).

Grinding cams, etc. F. PORSCHE GES. Brit. 485,534, June 1, 1938 (Nov. 28, 1936).

Grinding machine. J. Y. BLAZEK AND R. G. ANDERSON (Lempco Products, Inc.). U. S. 2,120,198, June 7, 1938 (July 23, 1934). C. J. HERTLEIN (Franz Fuchs). U. S. 2,118,304, May 24, 1938 (Oct. 3, 1936). C. H. RICHARDS (Heald Machine Co.). U. S. 2,119,290, May 31, 1938 (Dec. 21, 1936). W. D. SCHMIDT (Heald Machine Co.). U. S. 2,119,296, May 31, 1938 (Jan. 13, 1937). A. R. SPICACCI (General Motors Corp.). U. S. 2,118,902, May 31, 1938 (Aug. 1, 1935).

Grinding machine table reciprocating mechanism. NORTON CO. Brit. 485,611, June 1, 1938 (Nov. 20, 1936).

Grinding and polishing helical grooves. D. M. LIVSEY (Rheinmetall-Borsig Akt.-Ges. Werk Borsig, Berlin-Tegel). Brit. 484,784, May 25, 1938 (Oct. 28, 1937).

Grinding wheel. W. A. KERR AND R. A. GRUBBS. U. S. 2,119,279, May 31, 1938 (March 29, 1937).

Hand machine tools for filing purposes, etc. L. A. WILKIE. Brit. 485,328, June 1, 1938 (April 20, 1937).

Machine for grinding circular and noncircular work pieces. MAYER & SCHMIDT SCHLEIFMASCHINEN UND SCHMIRGELWERKE AKT.-GES. AND H. BUTTINGER. Brit. 484,450, May 18, 1938 (Sept. 30, 1937).

Machine for grinding flutes. S. W. BATH AND E. L. ACKLEY (John Bath & Co.). U. S. 2,118,139, May 24, 1938 (June 1, 1936).

Machine for grinding laminated articles. E. D. VANCIL (Cincinnati Grinders, Inc.). U. S. 2,118,369, May 24, 1938 (March 26, 1936).

Machine for grinding, polishing, burnishing, etc., of wire, rods, bars, etc. S. R. HOWES AND S. FOX & CO., LTD. Brit. 484,923, May 25, 1938 (Nov. 13, 1936).

Manufacture of cylindrical objects. F. W. WHITEHEAD AND W. T. GOODBY (Bristol Aeroplane Co., Ltd.). U. S. 2,118,959, May 31, 1938 (Nov. 22, 1937).

Polishing and buffing machine. G. A. CARLSON. U. S. 2,118,548, May 24, 1938 (Oct. 28, 1936).

Portable grinding machines, etc. G. H. THOMPSON. Brit. 485,224, June 1, 1938 (Feb. 26, 1937).

Precision grinding machines. CHURCHILL MACHINE TOOL CO., LTD., AND J. C. JONES. Brit. 485,323, June 1, 1938 (April 14, 1937).

Segmental abrasive wheel and method of making. A.

L. Ball and R. C. Benner (Carborundum Co.). U. S. 2,119,412, May 31, 1938 (Dec. 30, 1935).

Segmental grinding wheels. Norton Grinding Wheel Co., Ltd. Brit. 484,165, May 11, 1938 (Nov. 9, 1935).

Sharpener and device for honing lawn mowers. Frank Healy. U. S. 2,118,199, May 24, 1938 (July 1, 1935).

Skate sharpener. C. E. Nicolet. U. S. 2,118,617, May 24, 1938 (April 8, 1937).

Track grinder. H. J. Perazzoli. U. S. 2,118,621, May 24, 1938 (Feb. 15, 1935).

Valve-grinding machines. C. W. Brown and V. B. North. Brit. 484,002, May 11, 1938 (Oct. 28, 1936).

Art and Archeology

Artist in the glass industry. Wilhelm Wagenfeld. *Jour. Soc. Glass Tech.*, **20** [82] 751–57 (1936).—W. suggests collaboration of the buyer, technologist, and artist to advance the glass industry. See *Ceram. Abs.*, **16** [10] 293 (1937); **17** [2] 60 (1938). G.R.S.

Artistic British pottery. Anon. *Times Trade & Eng.*, **43** [891] xxxvi (1938).—Manufacturers, art directors, designers, and chemists coöperate in a constant endeavor to produce new and attractive shapes and patterns and to offer articles as tough and durable as possible while pleasing to sight and touch. Their moderate-priced grades are available in a wide and varying choice of design, pattern, and coloring. A.B.S.

Award for photos of executed examples of glass in architecture. Anon. *Architectural Forum*, p. 25 (Jan., 1938).—The contest is sponsored by the Pittsburgh Glass Institute and conducted by *Architectural Forum*. Prizes totaling $3600 will be awarded for photos of executed examples of decoration, architecture, and related subjects. Complete rules are given. The contest closes Nov. 1, 1938. G.L.S.

Ceramic discussions. Raoul de Blottefière. *Céram., Verrerie, Email.*, **5** [6] 205–11; [9] 291–95 (1937).—B. describes the operation of a faience plant at Choisi-le-Roi, France. See *Ceram. Abs.*, **16** [10] 293 (1937). M.V.C.

Ceramics and glass. S. Gille Delafon. *Clarté*, **11** [4] 7–11 (1938).—D. comments on ceramic and glass artistic works displayed at the Paris Exhibition (1937). Illustrated. R.W.D.

Chinese art of the Ming and Ch'ing periods. Helen Comstock. *Connoisseur*, **101** [441] 261 (1938).—An outstanding porcelain, the *blanc de Chine* Küan-yin of the Ming period, is illustrated. It is of Fukien ware, finely modelled in white paste glazed slightly green. An ovoid vase of the type emulating the Ku-yüeh hsüan glass is from the Ch'ien-lung period. M.E.P.

Chinese art treasures. Gunn Gwennet. *Clarté*, **11** [1] 3–7 (1938).—The possible destruction of Chinese art treasures is discussed. R.W.D.

Development in design of English glassware during the last hundred years. J. H. Hogan. *Jour. Soc. Glass Tech.*, **20** [82] 735–40 (1936).—The influence of taste and fashion on the design and decoration of glassware is pointed out. 7 figures. See *Ceram. Abs.*, **15** [4] 112 (1936). G.R.S.

Egyptian "nummi vitrei." O. Knapp. *Keram. Rundschau*, **45** [34] 384–85 (1937).—The nummi vitrei are glass pieces intended to check the weight of metallic coins. Of 320 specimens in the British Museum, only seven do not possess the correct weight. They were exclusively manufactured in Egypt from the 10th to the 13th Century. Although high in alkali and low in silica, the glass withstood weathering on account of 8.17 alumina. Dolomite was used in the batch. F.E.V.

Glass decoration in Germany. W. von Eiff. *Jour. Soc. Glass Tech.*, **20** [82] 741–50 (1936); see "Status—," *Ceram. Abs.*, **16** [9] 272 (1937). G.R.S.

Glass painting. E. Hamer. *Clarté*, **11** [1] 15–18 (1938).—H. discusses the artistic production of the Italian decorator, Glomi, in the 18th Century. Illustrated. R.W.D.

Improvement of glass. W. von Eiff. *Glashütte*, **68** [7] 108–13 (1938).—E. reviews the development of artistic glass by polishing, engraving, sandblasting, etching, etc. Illustrated. M.V.C.

Ingrand, glass decorator and enameler. S. Gille Delafon. *Clarté*, **11** [3] 3–7 (1938).—Max Ingrand's works are discussed. Illustrated. R.W.D.

Lorimer glass exhibition. Helen Comstock. *Connoisseur*, **97** [416] 217–18 (1936).—The English, Irish, and American glass belonging to George Horace Lorimer is the outstanding example of its kind on this side of the Atlantic. The most important piece is the Royal Oak Goblet commemorating the marriage of Charles II and Catherine of Braganza in 1663. There are many Williamite and Jacobite drinking glasses. M.E.P.

Origin, development, and present status of Newcomb Pottery. Kenneth E. Smith. *Bull. Amer. Ceram. Soc.*, **17** [6] 257–59 (1938).

Pottery figure of a horse. *Connoisseur*, **97** [413] 45 (1936).—Full-page illustration in color of a figure of the T'ang Dynasty, length 64 cm., from the Eumorfopoulos Collection. M.E.P.

Railway history in pottery. John Phillimore. *Connoisseur*, **101** [441] 242–51 (1938).—P. describes mugs, jugs, and bowls decorated with railway transfer scenes. These pieces were probably made as souvenirs. Most of this pottery is of Staffordshire origin, although some is from Liverpool and Leeds, dating from 1830 to 1845. Illustrated. M.E.P.

Rare pair of Whieldon brackets. Helen Comstock. *Connoisseur*, **97** [416] 221–22 (1936).—The fine quality of the glaze and the unusual treatment of the modelling make this pair of horse-head brackets valuable. Animal motifs appear often in Whieldon productions, *e.g.*, cow jugs, ducks as gravy boats, etc. M.E.P.

Report of the Jury of Awards for the first annual award of the Glass Medallion by Sidney Waugh. Anon. *Architectural Forum*, pp. 78–142 (Aug., 1937).—Photos of the grand prize winning picture and the winning picture in each classification for the use of glass in contemporary architecture and decoration are shown. G.L.S.

Russian collection. Helen Comstock. *Connoisseur*,

97 [416] 222 (1936).—One division of these Russian Imperial Treasures consists of examples of 18th and 19th Century table glasses, carafes, etc., produced chiefly at the Imperial Factory. Russian glassmaking owed its inception to Peter the Great, who summoned the Englishman, William Elmzel, to establish a factory in the province of Yamburg. After his death, 1738, this was taken over by the crown and moved in 1755 to St. Petersburg. There were other privately owned factories such as those of Prince Metchnikoff, Thomas Maltzoff, Michael Lomonosoff, and the Bakméteff family. Ornaments were confined to the Imperial eagle, crown, military emblems, monograms, and portrait medallions. The method of decoration is wheel engraving with characteristic Russian additions of black and gold. Illustrated. M.E.P.

Russian enamels. HELEN COMSTOCK. *Connoisseur*, **97** [415] 163 (1936).—Enameling was used in Russia upon objects for court ceremonials and liturgical and everyday uses. A few of the less pretentious but pleasing small objects of the 17th Century are illustrated, as well as a 19th-Century box of silver gilt, decorated in painted enamels, which bears the mark of a distinguished silversmith of Kiev, I. Marshak. The use of floral arabesques taken from Eastern textiles gives European enamels of the 17th Century a degree of similarity. In all, an outline of metal is used, achieved by casting as in England and Germany, by the champlevé process generally found in other parts of Europe, or by the cloisonné which Russia used to a great extent as well as the champlevé. A typical Russian element is the twisted wire border. M.E.P.

Sandblasting and other processes for decorating glass. SIGMUND POLLITZER. *Jour. Soc. Glass Tech.*, **20** [82] 724–34 (1936).—P. discusses embossing, brilliant cutting, and sandblasting. The advantages and limitations of each process are described. 7 figures. G.R.S.

Seated figure of a lohan. *Connoisseur*, **97** [414] 77 (1936).—Full-page color illustration of a pottery figure with colored glazes, 3 ft. 5 in. in height, T'ang Dynasty (A.D. 618 to 906). M.E.P.

Silver-mounted porcelain. EDWARD WENHAM. *Connoisseur*, **97** [416] 189 (1936).—Silver and silver-gilt mounts were added to Chinese porcelain and to European and Near Eastern pottery during the 16th Century. W. describes some of these rare Chinese porcelains. A celadon porcelain which is accepted as the earliest brought to England has a silver mounting which is gothic in character. Other pieces include Ming and Wan Li porcelains. M.E.P.

Silver-mounted pottery. EDWARD WENHAM. *Connoisseur*, **97** [417] 251–56 (1936).—There are three groups of pottery jugs with English 16th-Century mounts: (*a*) rare specimens from the Near East, painted with brilliant colored decorations and known as "Rhodian"; (*b*) stoneware made in Germany; and (*c*) finely glazed jugs mottled with dark blue, green, purplish black, red, and tones of brown from the early English potteries. The Rhodian ware body is usually white, of a loose sandy texture, varying from an opaque friable earthenware to a translucent semiporcelain, and is found in all parts of the Empire of the Ottoman Turks. It was brought to England from Gombroon during the reign of Queen Elizabeth by the East India Co. The mounts bear London hallmarks for 1586 to 1597. Most of the known specimens date from the second half of the 16th Century and are mounted with rich embossed, chased, and engraved designs on their covers, neckbands, and foot mounts. Illustrated. M.E.P.

Sung figurine of rare type. HELEN COMSTOCK. *Connoisseur*, **97** [415] 162 (1936).—In an exhibition of Chinese and Mohammedan art is a polychrome glazed figurine of a lady of rank assigned to the 12th Century A.D. Composed of buff earthenware of the Tzu Chou type, it is covered with a creamy white slip and has a decoration of red, green, and black under a clear glaze. This figurine shows the deft and lively touch of the contemporary and earlier terra cotta and predicts the charm of color of the Ming porcelain figures. Illustrated. M.E.P.

Statue of a judge of hell. *Connoisseur*, **97** [414] 95 (1936).—Full-page color illustration of a glazed stoneware statue, 4 ft. 6 in. in height, of the middle Ming period, in the British Museum. Reproduced from Chinese Art by R. L. Hobson. M.E.P.

Worcester vases. H. GRANVILLE FELL. *Connoisseur*, **97** [415] 169 (1936).—F. describes six Worcester pieces of important size and perfect quality made by Flight, Barr & Barr, including a pair of fruit coolers complete with liners and covers. They are richly decorated with painted flowers in natural colors, a gadrooned gold border, and a background of pale lemon. They are 13 in. high and have gilded twisted handles and a gold marbled ground inside the lips. M.E.P.

BOOKS

Stained glass of the 12th and 13th Centuries from the French cathedrals. M. AUBERT AND G. G. COULTON. B. T. Batsford, Ltd., London, 1938. 12 pp., 19 color plates. Price 10s 6d net. Reviewed in *Jour. Soc. Glass Tech.*, **22** [89] A70 (1938).

Stained glass of Yorkminster. F. HARRISON. Eight plates in color with introduction (8 pp.) and notes on the plates. Treasures of Art Series. Studio, Ltd., London, 1937. Price 7s 6d. Reviewed in *Jour. Soc. Glass Tech.*, **22** [89] A69 (1938).

PATENTS

Ceramic coloring matters. DEUTSCHE GOLD- UND SILBER-SCHEIDEANSTALT VORM. ROESSLER. Brit. 485,493, June 1, 1938 (Feb. 3, 1936).

Coating ceramic articles with metals. SIEMENS & HALSKE A.-G. Fr. 817,308, Sept. 1, 1937; *Chem. Abs.*, **32**, 2308 (1938).—Metals of high melting point, *e.g.*, Fe, Cr, Ni, or W (or an alloy thereof), are applied in the form of a fine powder on ceramic articles, which are then heated in an atmosphere free from O to the temperature of vitrifying fusion of the metal.

Decalcomania paper. JOHN MACLAURIN. Can. 374,050 and 374,051, May 24, 1938 (Jan. 2, 1936). G.M.H.

Decorating porcelain, etc. PORZELLANFABRIK F. THOMAS MARKTREDWITZ INH. PORZELLANFABRIK PH. ROSENTHAL & CO. A.-G. Ger. 655,505, Jan. 17, 1938; Cl. 80*b*. 23.01; *Chem. Abs.*, **32**, 3928 (1938).—Colored, especially cold colored, patterns are produced on ceramic ware by removing the glaze according to the pattern, applying the color or gilt, and reglazing.

Decoration of pottery articles. V. G. H. ALCOCK, R. B.

BLOORE, W. S. LINDLEY, AND P. R. BART. Brit. 483,763, May 11, 1938 (Jan. 13, 1937).

Designs for:

Ashtray. E. W. FUERST (Libbey Glass Co.). U. S. 109,909 and 109,910, May 31, 1938 (March 31, 1938). **Bottle.** E. M. COLEMAN (Owens-Illinois Glass Co.). U. S. 109,908, May 31, 1938 (April 6, 1938). A. I. LORENZEN (Owens-Illinois Glass Co.). U. S. 109,848, May 24, 1938 (March 21, 1938). C. A. WILLIAMS (C. M. Kimball Co.). U. S. 109,928, May 31, 1938 (April 6, 1938).

Coffeepot. W. D. HAVILAND (Theodore Haviland & Co., Inc.). U. S. 109,890, May 31, 1938 (Feb. 8, 1938). **Covered dish.** W. D. HAVILAND (Theodore Haviland & Co., Inc.). U. S. 109,889, May 31, 1938 (Feb. 8, 1938). **Goblet.** E. M. BOTTOME (Fostoria Glass Co.). U. S. 109,974, June 7, 1938 (April 14, 1938). R. R. KOSTELLOW (United States Glass Co.). U. S. 109,989, June 7, 1938 (April 8, 1938). NORMAN MOLL (Libbey Glass Co.). U. S. 109,990, June 7, 1938 (April 22, 1938). **Plate.** E. M. BOTTOME (Fostoria Glass Co.). U. S. 109,975, June 7, 1938 (April 14, 1938). C. W. LEIGH (Morimura Bros., Inc.). U. S. 109,894, May 31, 1938 (April 7, 1938). GEORGE SAKIER (Fostoria Glass Co.). U. S. 109,901, May 31, 1938 (April 20, 1938).

Cements

Petrographic study of clinker from a cement mill in Kramatorsk. A. M. TKACHENKO AND N. S. KOSTSOV. *Vsesoyuz. Nauchno-Issled. Inst. Tsementov*, No. 17, pp. 61–78 (1937).—The results of microscopic study of various kinds of clinker, their mineralogical composition, and their structural characteristics are discussed in detail.

M.V.C.

Theory of firing of Portland cement in automatic shaft kilns. V. N. YUNG. *Vsesoyuz. Nauchno-Issled. Inst. Tsementov*, No. 17, pp. 3–33 (1937).—Y. discusses experiments made to determine reactions taking place during firing of Portland cement in shaft kilns. 21 references.

M.V.C.

PATENT

Plaster of Paris compositions. GYPROC PRODUCTS, LTD., AND C. G. F. CAVADINO. Brit. 484,304, May 18, 1938 (Nov. 2, 1936).

Enamel

Analyzing and controlling metal cleaning operations. T. W. REESE. *Monthly Rev. Amer. Electroplaters' Soc.*, **24**, 83–94 (Feb., 1937); *Metals & Alloys*, **9** [4] MA236 (1938).—The essential factors in metal cleaning operations are discussed. Character of metal, size of article, foreign matter to be removed, equipment for different shapes, etc., are considered.

Composition of enamels. R. ALDINGER. *Keram. Rundschau*, **45** [39] 443–45 (1937).—A. gives batches for cover coats on sheet-iron utensils not subjected to fire and low-fired cover coats on sheet iron. Translucent and mat enamels are dealt with. F.E.V.

Enamel shop production problems. JAY SIMONS. *Enamelist*, **14** [11] 20–23 (1937).—As the modern enamel department is a service department to the assembly track, it must be adjusted to furnish the required parts without building up too great a cushion. Following an adjustment of the production of the various departments, the enameler must coördinate the operations necessary in the production of enameled ware. Data on pickling machines, the transfer type, running continuously, and the high-lift type, running intermittently, are presented. Suggestions on improving the efficiency of conveyers are given. A study of spray-booth equipment shows that while water-washed booths of the nozzle type are satisfactory for use on a conveyer line and the centrifugal type works well if water is to be used in individual spray booths, the most successful is the electrostatic precipitator type, which is adaptable to all kinds of booths. The prerequisites for color matching are discussed. E.J.V.

Enamelers of the 19th and 20th Centuries. GASTON RICHET. *Céram., Verrerie, Email.*, **5** [4] 129–35; [5] 165–71 (1937).—R. briefly discusses the life and methods of working of several great French enamelers. Illustrated. See *Ceram. Abs.*, **16** [10] 296 (1937). M.V.C.

England's first continuous furnace. ANON. *Enamelist*, **14** [11] 13 (1937).—The six-burner furnace installed at the Luton, Bedfordshire, plant of Electrolux, Ltd., is of the suspended roof or "U" type and is used for the production of refrigerator parts. Construction details are given.

E.J.V.

Films and their relation to cleaning before electroplating. C. JOHNSON. *Monthly Rev. Amer. Electroplaters' Soc.*, **24**, 520–37 (July, 1937); *Metals & Alloys*, **9** [4] MA236 (1938).—The various types of films found on metals and the theory and practice of metal cleaning are discussed in detail. Oil, fatty acid, soap, adsorbed gas, and other films which are both water repellent and wettable are treated.

Gas immersion heaters installed in pickle room. C. B. MERSHON. *Enamelist*, **15** [1] 23–26 (1937).—The pickling and cleaning department of the largest manufacturer of porcelain enameled hollow ware has been equipped with gas immersion heaters; it was formerly heated by steam from a central heating plant. The gas immersion units have effected more rapid boiling and elimination of dilution of the pickle and cleaning tanks with steam. Details of the construction of the heaters for different types of tanks are given. E.J.V.

Mechanical development of the enamel industry in the last 10 years. H. J. KARMAUS. *Sprechsaal*, **71** [1] 17–22 (1938).—German patents dealing with enamel kilns, firing, and the application of enamel are considered especially. See "Technical—," *Ceram. Abs.*, **17** [1] 9 (1938).

M.V.C.

Porcelain enamel in kitchens and baths. ANON.

Architectural Forum, pp. 315–22, 362–67 (Oct., 1937).—Illustrated. G.L.S.

Rational operation of mixing and melting. C. P. Ottersbach. *Glashütte*, **67** [50] 767–70 (1937).—O. discusses defects in enamels caused by unsatisfactory mixing and melting. M.V.C.

Significance of dedusting for the reuse of foundry sand. H. Köck. *Giesserei*, **25** [6] 137–38 (1938).—The recuperation of used foundry sand should remove all particles of less than 0.1 mm. grain size, which are defined as harmful dust. A normal foundry sand contains about 5 to 15% of this grain size, and by proper mixing of new and old dedusted sand a useful mixture for further foundry purposes can be obtained. A centrifugal dedusting apparatus is described. M.H.

Testing porcelain enameled utensils at the Good Housekeeping Institute. Christopher Brooks. *Enamelist*, **15** [2] 16–17 (1937).—Representative samples of enameled cooking ware are given a preliminary examination for fishscaling, surface imperfections, etc., which might lead to rapid deterioration of the enameled surface. To find the effect of food acids, tomatoes are boiled for 7 hr. in one pan, 1½ qt. of a 4% solution of acetic acid is boiled in another vessel for 7 hr., and a similar test with a 2% solution of citric acid is made. The amount of material extracted must not exceed 0.04 g./sq. in. of wetted surface. The porcelain enamel must contain no deleterious substances such as lead, arsenic, antimony, fluorine, etc., in harmful quantities. Actual kitchen tests are made for two months to check size, shape, weight, balance, durability, resistance to staining, cleanability, and suitability for its purpose. E.J.V.

Unusual application of automatic spraying of vitreous enamel slip. Wesley G. Martin. *Bull. Amer. Ceram. Soc.*, **17** [6] 255–57 (1938).

PATENTS

Apparatus for making sinks. V. J. Graf (Briggs Mfg. Co.). U. S. 2,120,094, June 7, 1938 (June 8, 1935).

Cast iron and the manufacture thereof. W. A. Brown (Carborundum Co.). U. S. 2,119,521, June 7, 1938 (Oct. 10, 1935). An ingredient for incorporation in the melt used for forming iron castings comprises a mass of silicon carbide and cement set to a cohesive article from a wet slurry.

Enameling iron. Jeno Kovács. Hung. 117,561, Jan. 15, 1938; *Chem. Abs.*, **32**, 3928 (1938).—Iron articles are surface oxidized by heating, treated with acid, washed, and dried at 100° to 150°. They are then coated with a suspension of quartz, feldspar, borax, AlF_3, soda, NiO, and CoO, etc., dried at room temperature, and heated to 70° to 100° and finally to 850° to 920°.

Manufacture of opacifiers for vitreous enamels. J. C. Arnold (Harshaw Chemical Co.). Brit. 484,562, May 18, 1938 (Jan. 3, 1938).

Vitreous compositions for making electric discharge lamps containing metal vapors. Compagnie des lampes and Compagnie française pour l'exploitation des procédés Thomson-Houston. Fr. 816,057, July 29, 1937; *Chem. Abs.*, **32**, 1419 (1938).

White clouded vitreous enamel. Ignaz Kreidl. U. S. 2,118,047, May 24, 1938 (Aug. 21, 1936). A vitreous enamel frit for the production of white clouded vitreous enamels for ironware, resulting from the melting and grinding of a mixture of ingredients containing at least silicates, borates, fluorine compounds, and aluminium compounds, the mixture containing cryolite in a proportion to provide elemental fluorine in a quantity of substantially 8 to 12% of the mixture, boron compounds in a proportion to provide boric acid in an amount not exceeding 10% of the mixture, and an aluminium oxide content derived from sources other than cryolite which is not greater than 7%, the amount of aluminium oxide from sources other than cryolite varying substantially from zero upward as the amount of boric acid decreases from 10% downward.

Glass

American literature on glass since 1915. S. R. Scholes. *Jour. Soc. Glass Tech.*, **21** [83] 82–86 (1937).—S. reviews the scope, sources, and trends of American literature on glass since 1915 and gives an account of the work of the Glass Division of the American Ceramic Society. Earlier literature has been superseded in almost all branches of glass technology and empiricism has given way to the application of strict scientific methods. G.R.S.

Architecture in glass. *Architectural Forum*, pp. 82–86 (Feb., 1937).—Photos of glass walls, floors, and furniture in England are shown. Panels, ceilings, walls, and doors in France and gilded and decorated glass on the Normandy are also illustrated. G.L.S.

Behavior of breaks in flat glass. G. Schieb. *Oesterr. Glaserztg.*, **3**, 38–42 (1938).—The literature is summarized and characteristics of breaks from various causes are shown. J.F.H.

Binding materials for assembling glass panels, etc. J. P. *Glaces & Verres*, No. 55, pp. 9–15 (1938).—P. describes manufacturing processes for the preparation of glue, gum, paste, cement, putty, etc., and the method of applying them. R.W.D.

Calculation of specific heats of vitreous silica and components of glasses as functions of temperature. Andre Thuret. *Jour. Soc. Glass Tech.*, **20** [82] 680–84 (1936); see *Ceram. Abs.*, **15** [10] 313 (1936). G.R.S.

Clock glass grinding in all forms. G. S. *Deut. Glaserztg.*, **48**, 316–17 (1937).—S. describes a grinding machine for edge grinding of clock glasses in square, rectangular, round, and elliptical shapes and their variations. To bend the glasses to shape a small bench electric furnace was employed, the glasses being heated on iron or ceramic formers. A gas furnace was equally suitable. E.P.

Completely automatic glassblowing machines in Germany. Anon. *Sprechsaal*, **71** [1] 22–24 (1938).—Details of construction and operation of 3 German automatic glassblowing machines are given. M.V.C.

Czechoslovak protective glasses for goggles. V. Čtyroký and M. Fanderlik. *Skláfské Rozhledy*, **15**, 8–13 (1938).—A new range of glasses, Glass Ophthalmoprotekt,

comprises ten members of a series of ultra-violet absorbing glasses for use as eye-protecting goggle glasses according to the German standard DIN 4646. The spectral absorption or coloring of the glasses is expressed as coloring = 2 − log % transmission. Curves show the spectral absorptions of the series of glasses from 0.2 to 2.0 μ (visible spectrum = 0.4 to 0.8 μ). For measurements in the ultra-violet and visible spectrum, Foma-Panchro-Isolar plates are used in the spectrograph while for measurements in the infra-red, Agfa-Infrarot-810 plates are employed. E.P.

Czechoslovak signal glasses. V. Čtyroký and M. Fanderlik. *Jour. Soc. Glass Tech.*, **21** [83] 95–112 (1937); *Sklářské Rozhledy*, **14**, 1–5, 25–30, 47–52 (1937).—The desirable properties of red, green, blue, and yellow railway signal glasses, operating with kerosene, acetylene, and electric lights, are discussed. The determination of light transmission curves materially assists in the specification of the desired properties, and by this means specifications for the Czechoslovak railways have been drawn up for green and blue signal glasses defining their transmission limits between 4000 and 7600 Å. G.R.S. + E.P.

Decolorization of glass. H. Stransky. *Keram. Rundschau*, **45** [45] 515–16; [47] 541–42 (1937).—S. gives an outline of this problem largely based on Glastechnische Fabrikationsfehler (*Ceram. Abs.*, **16** [1] 16 (1937)). The factors affecting the grade of oxidation of iron are discussed, and the chemical and physical decolorizations are considered with special reference to selenium and rare earths. F.E.V.

Defects forming in glass when worked over a blast lamp. Kurt Mayer. *Glashütte*, **67** [40] 619–23 (1937).—The formation and causes of roughness, blisters, and froth on glass surfaces when worked over a blast lamp are reviewed, and explanations by various investigators are given. M.V.C.

Development of machinery in the glass industry in the last 10 years according to German patent literature. J. Thierry. *Sprechsaal*, **71** [1] 5–17 (1938). M.V.C.

Elastico-viscous properties of a soda-lime-silica glass at temperatures near the "transformation point." N. W. Taylor, E. P. McNamara, and J. Sherman. *Jour. Soc. Glass Tech.*, **21** [83] 61–81 (1937).—Isothermal creep tests of stabilized fibers of a soda-lime-silica glass have been made in the range 475° to 525°. Elongation is due to viscous flow at constant rate plus completely reversible elastic distortion, instantaneous and delayed. For the latter, $dl/dt = kl$, l being the unstretched part at time t, and $\log k = A'/T_{abs.}$ + constant, where $A' = 8.05 \times 10^4$. This relation shows no break at the "transformation point," 515° (from thermal expansion), but above 515° the rates are rapid (large values of k) and the glass acts like an ordinary liquid. Young's modulus, based on the total elastic distortion, appears independent of temperature. The slope of the log η *vs.* $1/T_{abs.}$ curve for viscous flow is 7.04×10^4. An ionic picture of the elastic process is given. G.R.S.

Electrical conductivity of thin films of alkali metals spontaneously deposited on glass surfaces. A. C. B. Lovell. *Proc. Phys. Soc.* [London], **49** [271] 89–94 (1937).—L. describes an investigation of the electrical conductivity of invisible thin films of alkali metals which are deposited spontaneously on the wall of an enclosure in which they are sealed *in vacuo*. The resistivity of the films decreases in the order of potassium, rubidium, caesium. The resistivity of the rubidium film is in reasonable agreement with a previous measurement given by Ives and Johnsrud; some evidence is adduced in support of their view that the thicknesses of these spontaneous deposits are of the order of those of monatomic layers. Curves show the resistance of deposited films at various temperatures for rubidium on soda glass, caesium on Pyrex glass, and caesium on soda glass. See *Ceram. Abs.*, **16** [11] 333 (1937). L.E.T.

English looking-glass plates and their manufacture. R. W. Symonds. *Connoisseur*, **97** [417] 243–49 (1936).—There were two methods of manufacturing looking-glass plates in the 17th and 18th Centuries in England. The first, earlier and less efficient, was by blowing glass into cylinders which were afterward cut and flattened out; this made the plate of large proportions not thick enough to bear grinding and with a tendency to warp. The second, later and better, was by casting, invented by Abbé Thevart in 1688 and first used in France. In 1761 plates of glass for coach windows and looking-glasses were cast in the same manner in which a plumber casts sheets of lead. Taxes on home production and raw materials, expense of outlay, conservatism, and lack of enterprise prevented English glassmakers from using the casting process for larger plates during the first half of the 18th Century. In 1773, however, a new company set out to make plate glass by casting on a large scale and succeeded beyond precedent. The cost of the plant was £ 50,000. Dimension limits were 82 x 48 in. in 1761, 142 x 72 in. in 1869, and 288 x 168 in. in 1924. Illustrated. M.E.P.

Experimental and research departments of the German State Technical School for the Glass Industry in Steinschönau. A. Hübler. *Tchéco-Verre*, **4**, 65–68 (1937).—H. describes instruction and training given in glassmelting, cutting, engraving, painting, and sandblasting. E.P.

Fiber glass as insulator for electric apparatus. K. N. Mathes. *Gen. Elec. Rev.*, **41** [5] 218–19 (1938).—M. discusses the manufacture of fiber glass and of glass in general for electric insulation. Textile fiber (alkali-free) glass has good mechanical and electrical properties and high resistance to deterioration at high temperature. Up to the yield point (between 500° and 600°C) no appreciable flow occurs. If fiber glass is rubbed or abraded, it will nick and break. A varnish or compound treatment will prevent this mechanical destruction. A table shows the comparative tensile strengths for 1 in. wide tape of fiber glass, asbestos, and cotton. L.E.T.

Flow of glass in tanks. A. L. Marden. *Jour. Soc. Glass Tech.*, **20** [82] 676–79 (1936).—Proposals are made for the design of a tank furnace in which lateral currents are developed to a greater degree than usual to minimize longitudinal channeling. Batch feeding from several points instead of a single doghouse is advocated. New furnace designs are illustrated. G.R.S.

Fourier analysis of X-ray patterns of soda-silica glass. B. E. Warren and J. Biscoe. *Jour. Amer. Ceram. Soc.*, **21** [7] 259–65 (1938).

Glass age in moving-picture industries. S. Maufras. *Clarté*, **11** [4] 16–19 (1938).—M. emphasizes the uses of plate glass in moving-picture studios. Illustrated. R.W.D.

Glass, the building material of the 20th Century. K. K. PERSLEE. *Tchéco-Verre*, **4**, 99–101, 115–17 (1937).—P. discusses the increasing use of glass in decorative forms for domestic, public, and works buildings. E.P.

Glass for constructional purposes. J. POLÍVKA. *Jour. Soc. Glass Tech.*, **20** [82] 764–68 (1936); see "Glass in modern—," *Ceram. Abs.*, **15** [11] 330 (1936). G.R.S.

Glass decorative methods in Bohemia in the Empire and Biedermeier periods. F. X. JIRIK. *Jour. Soc. Glass Tech.*, **20** [82] 758–63 (1936); *Tchéco-Verre*, **4**, 3–6 (1937).—The glass industry of Bohemia became famous in the 17th and 18th Centuries. Means of competing with the lead crystal glass in the 19th Century were found by improving the Bohemian potash-containing glass and glass coloring processes. The development of cased glass and the application of various finishing processes created a new popular art. G.R.S. + E.P.

Glass grinding and cutting tools. A. GUILLEAUME. *Jour. Soc. Glass Tech.*, **20** [82] 717–23 (1936).—The different kinds of abrasive wheels employed in glassworking are considered. Factors governing the choice of material are the effect desired, the fineness of grinding, and the time and area of contact between the tool and the work. Facet grinding, grinding of jar and mouth edges, spectacle lens edging, crystal "cutting," and slitting are discussed. G.R.S.

Glass as industrial material. A. FEHSE. *Maschinenbau*, **17**, 27–29 (1938); abstracted in *Chem. Zentr.*, **1938**, **i**, 2772.—F. discusses rolling, boring, and milling of glass with hard metal tools, the cutting, grinding, and bending of glass pipes, and the cementing of glass with metallic parts. M.V.C.

Glass at Paris International Exhibition. ANON. *Deut. Glaserztg.*, **48**, 351 (1937).—The glass house erected by St. Gobain is described. Brown porous glass brick having only one-tenth the weight of ordinary glass brick are used in the interior. E.P.

Glass silvering since 1930. WALTER WAGNER. *Kolloid-Z.*, **82**, 378–80 (1938); *Chem. Abs.*, **32**, 3565 (1938).

Hardness of glasses. M. PIRANI AND A. FEHSE. *Glastech. Ber.*, **14**, 21–22 (1936).—A series of 5 Jena glasses was studied to devise a means of measuring working hardness of glasses. Glass rolls 47 mm. in diameter were turned in a lathe. The cutting tool was a slightly beveled disk (20 mm. in diameter, 4 mm. thick) which could be turned to give a fresh cutting surface for each test. Cuts 0.5 mm. deep with a feed of 0.127 mm. were taken for 110 mm. along the rod. Dulling of the cutting edge as determined microscopically was used as a measure of hardness. Great differences in hardness were noted, but the order of hardness was not always reproducible. Boring experiments, however, were reproducible to around 20% and gave a very definite order of hardness, the measure being depth of penetration with, *e.g.*, a load of 10 kg. and a speed of 700 r.p.m. A glass which was softer according to boring tests was harder in the matter of grinding. The term "hardness" should be dropped in favor of more specific terms such as "boring hardness." J.F.H.

Heat-absorbing glasses. V. ČTYROKÝ AND M. FANDERLIK. *Sklářské Rozhledy*, **14**, 69–73 (1937).—Test results on the heat-absorbing glasses, Dethermalglas L and Dethermalglas N, made by Bilinskasklarna Engels and Co., are as follows:

Glass	Transmission: Total radiation (%)	Transmission: Light radiation (%)
Sunlight		
Dethermalglas L	27.4	61.3
Dethermalglas N	13.6	36.4
Electric arc		
Dethermalglas L	13.8	56.5
Dethermalglas N	4.8	32.9

With unfavorable conditions (wind normally giving adequate cooling), the greatest amount of heat which could penetrate into a room was 86.0 for ordinary window glass, 59.7 for Dethermalglas L, and 52.6% for Dethermalglas N. Better results were obtained by double glazing, the outer window being of Dethermalglas and the inner of ordinary window glass. Double window glazing with ordinary window glass let through a maximum of 76.7% of the incident radiation; with Dethermalglas L on the outside this was reduced to 41.3%, and with Dethermalglas N it was reduced to 32.1%. Dethermalglas L was only faintly green, while Dethermalglas N was more deeply colored. E.P.

Heat-resisting steels for the glass industry. R. J. SARJANT AND T. H. MIDDLEHAM. *Jour. Soc. Glass Tech.*, **20** [82] 685–716 (1936).—The properties required in heat-resisting materials for medium and high temperature operations are reviewed with reference to composition, thermal conductivity, changes occurring on heating, microstructure, strength at high temperatures, resistance to scaling, the effects of repeated heating and cooling, and the bearing of structural changes. An account is given of the performance of heat-resisting alloys in service. New experimental methods of investigation are described relating to resistance to the effects of repeated heating and cooling and to the attack by molten glass on materials suitable for the tools and equipment used. 33 Figures. G.R.S.

Importance of rare earths for the glass industry. V. ČTYROKÝ. *Sklářské Rozhledy*, **15**, 23–33 (1938).—Rare earths are used in the glass industry for the production of glasses of specific colors, *e.g.*, signal glasses, decolorizing, and the production of glasses of special physical and optical properties. Didymium is a mixture of neodymium and praseodymium and is used to give a neutral gray glass. Cobalt and cerium oxides give a blue glass (Jena blue), and chromium and cerium a green glass. Glasses containing 2 to 4% Ce_2O_3 absorb the ultra-violet, and the use of glasses decolorized by cerium oxide in place of manganese reduces the coloration of glass by exposure to X-ray radiation. Cerium oxide is also used in the production of fluorescent glasses for modern mercury-vapor discharge tubes. E.P.

Investigating glass currents in tank furnaces. W. SCHNEEKLOTH AND W. SPIELVOGEL. *Jour. Soc. Glass Tech.*, **20** [82] 651–75 (1936); see *Ceram. Abs.*, **16** [7] 202 (1937). G.R.S.

Laboratory apparatus and application of filter of porous glass. H. PRAUSNITZ. *Chimica & Industria*, **19** [10] 569–74 (1937). M.H.

Manufacture of nonbreakable and noncracking glass. LUDVÍK ŠPIRK. *Chem. Listy*, **31**, 425–30 (1937); *Chem. Abs.*, **32**, 3565 (1938).—S. discusses the manufacture of Et acrylate, Me acrylate, and their polymers for use in laminated glass and of diacetone alcohol, $C_2H_3Cl_4$, methylcyclohexanone, and cyclohexanone as solvents for the preceding bases.

Maximum bubble pressure (Jaeger) method for measuring the surface tension of molten glass. C. W. PARMELEE AND K. C. LYON. *Jour. Soc. Glass Tech.*, **21** [83] 44–52 (1937).—A method is described for determining the surface tensions of molten glasses by measuring the maximum pressure within a bubble formed at the end of a platinum-rhodium tube which just touches the surface of the glass. The results obtained indicate an almost linear decrease of density and surface tension with increasing temperature from 1050° to 1350°. The limiting surface tension values at these temperatures are approximately 260 and 244 dynes per cm., respectively, for the glass composition investigated. G.R.S.

Parabola. ANON. *Amer. Architect*, p. 23 (Jan., 1938).—This film shows a study in light and form as transmitted by glass. G.L.S.

Parisio's engraved and decorated glass panels. ANON. *Glaces & Verres*, No. 54, pp. 8–12 (1938).—L. Parisio's personal and original method for decorating sheets of glass by the sandblasting process is described. Illustrated. R.W.D.

Photos of houses and interiors using glass-block walls. *Architectural Forum*, p. 108 (Feb., 1937). G.L.S.

Production of milk bottles of good quality. DEUT. FLASCHENVERKAUFS G.M.B.H. *Proc. World's Dairy Congr., 11th Congr., Berlin*, **3**, 380–84 (1937); *Brit. Chem. & Phys. Abs.–B*, **57** [4] 371 (1938).—The properties of glass for food processes and containers are described. Milk bottles which have to be subjected to rough handling must be made of glass which resists scratching, starring, and pitting; the alkali content, particularly low Na_2O, must be carefully controlled.

Proposals for a standard basis for the expression of tank furnace performances. W. A. MOORSHEAD. *Jour. Soc. Glass Tech.*, **20** [82] 640–50 (1936).—M. proposes a formula as a standard means of expressing furnace performance. The data from 19 furnaces examined by means of this formula show that larger furnaces are normally more efficient than smaller ones. The controlling factor in furnace performance is furnace load, and proposals are made whereby it can be brought to a common basis for the comparison of different furnaces. It is suggested that calculations of furnace efficiency should be based on data obtained during the first third of the expected furnace life. G.R.S.

Safety glass for automobiles. HEINZ FEIST. *Nitrocellulose*, **8**, 119–22 (1937); *Chem. Abs.*, **32**, 3565 (1938).

Siliceous and aluminous raw materials. RUDOLF SCHMIDT. *Glashütte*, **68** [7] 116–19 (1938).—S. discusses experiments made in Russia, England, U.S.A., and Italy dealing with the removal of iron from sand, the effect of its moisture content, and the use of feldspar, pegmatite, nepheline, pyrophyllite, and blast-furnace slag in glass manufacture. The chief requirements for raw materials used in glass and enamel manufacture are (1) known chemical composition for computing batches; (2) invariable composition; (3) quantitative determination of injurious admixtures, for the purpose of obtaining the lowest possible iron content for colorless glass and enamel; and (4) suitable granulation. M.V.C.

Softening of glasses at high temperatures. I. SAWAI AND I. KUBO. *Jour. Soc. Glass Tech.*, **21** [83] 113–22 (1937).—A method is described by which the behavior of a glass at high temperatures associated with softening and devitrification may be rapidly determined. Variations in the dimensions of the test pieces are due to the combined effects of the properties viscosity and surface tension, and the behavior of glasses of different types depends on these properties. The lower temperature limit of devitrification may be reduced slightly on prolonged heating, but the upper temperature limit is almost unaffected by such treatment. G.R.S.

Specifications for lead glasses in Czechoslovakia. V. ČTYROKÝ AND M. FANDERLIK. *Sklářské Rozhledy*, **13**, 129–33 (1936); see *Ceram. Abs.*, **16** [8] 241–42 (1937). E.P.

Spun rock wool. C. R. BUSS. *Sands, Clays & Minerals*, **3** [3] 231–32 (1938).—Mineral wool was first produced in America 70 years ago. Rock wool was made by melting the rock in a cupola furnace with alternating layers of rock and coke. As the molten stream left the furnace, a jet of high-pressure steam or compressed air was directed against it, producing fine threads and tiny beads. M.H.

Stained glasses and the glassworks of Saint-Just-sur-Loire. G. CHASTEL. *Glaces & Verres*, No. 55, pp. 2–5 (1938).—C. describes manufacturing processes. R.W.D.

Strength and homogeneity of glass. ANON. *Sklářské Rozhledy*, **13**, 119–22 (1936).—It is necessary to distinguish between the tensile and compressive strengths of glass according to the purpose for which it is to be employed. Birefringence measurements on mechanically strained glass can be used to determine the strength. E.P.

Surface tension of glass. G. KEPPELER. *Jour. Soc. Glass Tech.*, **21** [83] 53–60 (1937).—Two methods have been employed for the determination of the surface tensions of six boric oxide-containing glasses, varying from 0 to 9.05 B_2O_3. At 1400° the values obtained by the bubble method were approximately twice the values obtained by a fiber method. Increasing the B_2O_3 content of the glasses decreased in a regular manner the surface tension measured by either method. The cause of the discrepancy in the results of the two methods remains uncertain. G.R.S.

Surface working of flat glass by grinding. O. HERFURTH. *Diamant*, **59**, 194, 203–204, 213–14, 224–25, 236, 268–69, 273–74 (1937); see *Ceram. Abs.*, **17** [1] 14 (1938). E.P.

Technical proposals and data for an examination of the thermal performance of glassmelting tanks. W. FRIEDMANN. *Jour. Soc. Glass Tech.*, **20** [82] 596–639 (1936).—F. stresses the need for greater uniformity both in definitions and in methods of calculating practical indices of performance in order to facilitate a systematic improvement in tanks. A numerical example shows how the results of practical investigations can be used in a simple manner to (*a*) form a comparative opinion of the thermal

conditions in a furnace, and (*b*) calculate, approximately, in advance the thermal effects of constructional features and constructional alterations and the possible effects of thermal improvements. Proposals are made for the calculation of average indices for standard values of specific melting load, of efficiency of regeneration, and of "useful heat" per kilogram of glass when they are needed for comparison. G.R.S.

Tests of Owens-Illinois glass block construction. D. H. MERRILL. *Bldg. Standards*, **6** [6] 7–9 (1937); *Jour. Soc. Glass Tech.*, **22** [89] A19 (1938).—M. describes hollow glass blocks tested and gives an account of compression tests of individual blocks and small panels, shear tests of mortar joints, bending tests of full-sized wall panels, and compression and tension tests of mortar cylinders and briquets. The results are tabulated. Illustrated.

Theory of decolorizing with selenium. A. DIETZEL. *Jour. Soc. Glass Tech.*, **21** [83] 87–94 (1937).—On cooling glasses containing iron oxide and selenium, FeSe is formed, the more rapidly, the more reducing are the melting conditions. The presence of this compound is an important factor in selenium decolorizing. Glasses of finest colorless appearance are produced under strongly oxidizing melting conditions but are liable to the development of objectionable colors on annealing; therefore, weakly oxidizing conditions are employed, and the yellow or brownish tint usually resulting from the use of selenium alone is neutralized by the introduction of a small amount of cobalt oxide to give a glass of neutral tint. See "Researches—," *Ceram. Abs.*, **15** [3] 89 (1936). G.R.S.

Turned and milled glass. A. EWALD. *Deut. Glaserztg.*, **48**, 311–15 (1937).—Glass turning and milling using Widia steel tools are described. A dish turned from lead crystal glass was produced at a 50% saving in cost compared with the ordinary grinding method. See "Hard—," *Ceram. Abs.*, **16** [7] 194 (1937). E.P.

Unusual air-conditioning problems met in designing glass block building. JAMES N. LIVERMORE. *Heating, Piping & Air Conditioning*, **10** [4] 241–45 (1938).—L. discusses the special air-conditioning problems encountered in the Detroit Edison Company's new service building. Illustrated. J.L.G.

Use of glass in broadcasting studios. ANON. *Architectural Forum*, p. 147 (Feb., 1938).—Photos of station KSOO showing the use of glass blocks for interior partitions and decorations are shown. G.L.S.

Viscosity of glass. P. GILARD, L. DUBRUL, G. HENRY, SCOHY, AND PIÉRET. *Bull. Soc. Chim. Belg.*, **46** [11] 435–70 (1937).—The authors deal with the exact temperature measurements in the mass of the glass in previous tests on methods of measuring viscosity (*Ceram. Abs.*, **16** [4] 116 (1937)). Thermocouples used, the method of calibration, and the derivation of formulas employed are discussed in detail. The test results on a glass containing 70.90 SiO_2, 11.96 Na_2O, 16.51 CaO, 1.10 MgO, 0.26 Fe_2O_3, 0.81 Al_2O_3, and 0.45% SO_3 are reproduced in a curve, temperature *vs.* log of viscosity from 815° to 1300°C. Another curve shows the velocity of devitrification as a function of temperature which has a maximum at 950°. M.H.

Windshields of safety glass only. H. MERTENS. *Deut. Glaserztg.*, **48**, 464–65 (1937).—All power-driven vehicles in Germany are required by law to have windshields and interior glazing of safety glass. In terms of the act, safety glass denotes glass or any glasslike material which, when fractured, could cause no serious injury. M. describes the manufacture and properties of safety glass and toughened glass and gives details of the cutting, drilling, and fitting of these glasses. E.P.

Yellow-green bottle glass from blast-furnace slag without pyrolusite. L. SPRINGER. *Keram. Rundschau*, **45** [36] 410 (1937).—The substitution of slag for pyrolusite is possible in the manufacture of yellow-green glass. F.E.V.

BOOKS

Course in Physical Chemistry of Glass (Cours de Physico-Chimie du Verre). P. GILARD. Maison Desoer, Liége, 1936. 2 vols. 281 pp. Reviewed in *Glashütte*, **68** [1] 11 (1938).—This book comprises a series of lectures delivered at the University of Liége, Belgium, on the physical chemistry of glass. Volume I deals with the scientific principles of the glass industry, aggregates, viscosity, materials forming glass, reactions occurring during melting, and silicates. Volume II is devoted to devitrification, glass defects, annealing, physical and chemical properties of glass, coloring, decoloration, and opacification. M.V.C.

Handbook of Glasspainting (Handbuch der Glasmalerei). JOSEF LUDWIG FISCHER. K. W. Hiersemann, Leipzig, 1937. 2d ed. viii + 296 pp., 55 illustrations, 124 plates. Price 22 Rm in Germany; 16.50 Rm in Great Britain. Reviewed in *Jour. Soc. Glass Tech.*, **22** [89] A69 (1938).

PATENTS

Agitator for producing uniform mixtures of molten glass in the furnace. SOC. ANON. DES MANUFACTURES DES GLACES & PRODUITS CHIMIQUES DE ST. GOBAIN, CHAUNY & CIREY. Ger. 654,519, May 21, 1935; Cl. 32*a*. 5; *Chem.-Ztg.*, **61** [99] 975 (1937). D.A.B.

Apparatus for:

Annealing drawn glass. N. V. HOLLANDSCHE MIJ. VOOR DE VERVAARDIGING VAN GLAS. Fr. 816,073, July 29, 1937; *Chem. Abs.*, **32**, 1420 (1938). This corresponds to Brit. 469,668, Aug. 11, 1937.

Forming tensionless glass fibers. TECHNOVA PATENT UND NEUHEITEN EXPORT G.M.B.H. AND HANS J. BLUM. Ger. 654,644, Dec. 28, 1937; Cl. 32*a*. 25; *Chem. Abs.*, **32**, 3568 (1938).

Making colored or modified glass by adding coloring or modifying substances to fused glass. JOHANN GUNKA. Austrian 151,818, Dec. 10, 1937; Cl. 32*c.*; *Chem. Abs.*, **32**, 2307–2308 (1938).

Making glass tubes or cylinders. CORNING GLASS WORKS. Fr. 819,677, Oct. 23, 1937; *Chem. Abs.*, **32**, 2307 (1938).

Tempering sheets of glass. PIETRO MELCHIORRE. Fr. 820,928, Nov. 22, 1937; *Chem. Abs.*, **32**, 3569 (1938).

Tempering sheets of glass by jets of air, etc. LENNOX HASSAN. Fr. 818,245, Sept. 21, 1937; *Chem. Abs.*, **32**, 2308 (1938).

Use in treating glass sheets. I. G. FOWLER (Libbey-

Owens-Ford Glass Co.). U. S. 2,118,183, May 24, 1938 (Dec. 24, 1934). An apparatus for supporting a glass sheet in a vertical position during tempering.

Blown glass article manufacturing machine. EMILE ROIRANT (Soc. Anon. d'Études et de Constructions d'Appareils Mécaniques pour la Verrerie). Can. 374,004, May 24, 1938 (April 14, 1936). G.M.H.

Bottom closure of glassware forming mold. G. E. HOWARD (Hartford-Empire Co.). U. S. 2,118,793, May 24, 1938 (Nov. 10, 1936).

Ceramic mold. GEORGE V. MCCAULEY (Corning Glass Works). Can. 373,947, May 24, 1938 (June 17, 1937; in U. S., Aug. 4, 1936). G.M.H.

Coated glassware. A. H. STEWART (Phoenix Glass Co.). U. S. 2,119,608, June 7, 1938 (July 8, 1935). A shaped glass article has a portion of its surface coated with metal sprayed thereon while the article is still hot from the shaping thereof and an outer protective coating of translucent tinted material applied to the metal coating, giving color effects to light rays that pass through minute openings in the metal coating.

Colored glass. AMERICAN SECURIT CO. Fr. 818,164, Sept. 20, 1937; *Chem. Abs.*, **32**, 2307 (1938).—Glass is colored by spraying with a vitreous coating and cooling. The vitreous coating is sprayed in a fused state and the glass receiving it is heated almost to the softening point. The whole is then cooled after spraying.

Continuous process for making sheets of multicellular glass. R. J. A. INGOUF (Blue Ridge Glass Corp.). U. S. 2,118,707, May 24, 1938 (March 2, 1936).

Drawing glass into sheets. UNION DES VERRERIES MÉCANIQUES BELGES (SOC. ANON.). Fr. 817,825, Sept. 11, 1937; *Chem. Abs.*, **32**, 2307 (1938).

Electric furnace for tempering sheets of glass. PIETRO MELCHIORRE. Fr. 820,778, Nov. 18, 1937; *Chem. Abs.*, **32**, 3568 (1938).

Feed-regulating mechanism of machines for making glass bottles. W. E. EVANS (F. O'Neill). Brit. 484,674, May 18, 1938 (Nov. 6, 1936).

Flat glass polishing apparatus. JAMES H. GRIFFIN (Pilkington Bros., Ltd.). Can. 373,988, May 24, 1938 (Feb. 2, 1937). G.M.H.

Forehearth for molten glass. WILLIAM T. HONISS (Hartford-Empire Co.). Can. 373,964, May 24, 1938 (May 27, 1937). K. E. PEILER AND W. T. BARKER, JR. (Hartford-Empire Co.). Can. 373,965, May 24, 1938 (May 27, 1937). G.M.H.

Forming hollow-ware by casting molten glass. NEUE GLASINDUSTRIE-GES. G.M.B.H. Ger. 653,466, Nov. 11, 1937 (Aug. 17, 1934); N 37,030, VI/32*a*, Gp. 24_{04}; *Jour. Soc. Glass Tech.*, **22** [89] A37 (1938).—In a process for forming hollow glass articles, the glass layer is cast around a core in a mold.

Fusing and degasifying glass. V. E. BROMLEI. Russ. 35,980, April 30, 1934; *Chem. Abs.*, **32**, 3568 (1938).—Construction details of a glassmelting furnace with the recirculation of the molten mass by means of vacuum are given.

Fusion furnace for silicate glass. GEORG ZOTOS. Fr. 817,479, Sept. 3, 1937; *Chem. Abs.*, **32**, 2307 (1938).—Heating means is described.

Glass. CORNING GLASS WORKS. Ger. 654,973, Jan. 5, 1938; Cl. 32*b*.1; *Chem. Abs.*, **32**, 3568 (1938). See Brit. 455,082, Oct. 28, 1936.

Glass article tempering method. CHARLES J. PHILLIPS (Corning Glass Works). Can. 373,948 and 373,949, May 24, 1938 (Sept. 11, 1937; in U. S., Nov. 11, 1936). G.M.H.

Glass batch. H. P. EELLS, JR., AND H. N. BARRETT (Basic Dolomite, Inc.). Can. 373,921, May 24, 1938 (April 8, 1937). G.M.H.

Glass building block. J. H. FOX (Pittsburgh Plate Glass Co.). U. S. 2,118,643, May 24, 1938 (Sept. 12, 1936).

Glass cutting apparatus. G. L. LEE (Landon P. Smith, Inc.). Can. 373,840, May 17, 1938 (Aug. 23, 1937). G.M.H.

Glass drawing apparatus. DAVID E. GRAY (Corning Glass Works). Can. 373,944, May 24, 1938 (March 2, 1937; in U. S., April 10, 1936). WILLIAM J. WOODS (Corning Glass Works). Can. 373,946, May 24, 1938 (May 15, 1937; in U. S., July 7, 1936). G.M.H.

Glass fibers. SOC. ANON. DES MANUFACTURES DES GLACES & PRODUITS CHIMIQUES DE ST. GOBAIN, CHAUNY & CIREY. Fr. 819,447, Oct. 19, 1937; *Chem. Abs.*, **32**, 2307 (1938).—The free alkali at the surface of glass fibers to be used as heat-insulating material, in filters, etc., is neutralized by an acid which may be incorporated with a plastic material or oily substance used for coating the fibers. An organic acid, such as stearic, abietic, or oleic, may be used. NH_4Cl or $(NH_4)_2SO_4$ may be used in place of an acid, NH_3 being evolved. The coating may be applied as an emulsion containing an emulsifying agent such as a soluble soap or triethanolamine. Fire-proofing agents, bactericides, fillers, etc., may be added to the emulsion.

Glass furnace. HENRY H. BLAU AND KENNETH K. KNAELL (Corning Glass Works). Can. 373,980, May 24, 1938 (Dec. 4, 1936; in U. S., June 8, 1936). G.M.H.

Glass furnace provided with gathering basins. SOC. CONTINENTALE D'APPAREILS MÉCANIQUES POUR LA VERRERIE SOC. ANON. Brit. 484,350, May 18, 1938 (Dec. 17, 1936).

Glassmelting tank. HENRY H. BLAU AND KENNETH K. KNAELL (Corning Glass Works). Can. 373,978, May 24, 1938 (Dec. 4, 1936; in U. S., June 8, 1936). G.M.H.

Glass sheets. AUSTRALIAN WINDOW GLASS PTY., LTD. Australian 102,275, Oct. 28, 1937; *Chem. Abs.*, **32**, 2307 (1938).—After it is drawn but before it leaves the drawing pit, glass sheet is cooled to the temperature of the upper annealing range. The length of the leer can thus be reduced. Apparatus is described in detail.

Glass tempering method. EDWIN M. GUYER (Corning Glass Works). Can. 373,943, May 24, 1938 (Nov. 10, 1936). G.M.H.

Glass treating apparatus. HENRY H. BLAU AND KENNETH K. KNAELL (Corning Glass Works). Can. 373,977 and 373,979, May 24, 1938 (Dec. 4, 1936; in U. S., June 8, 1936). G.M.H.

Glassworking machine. HAROLD H. SNYDER (Corning Glass Works). Can. 373,945, May 24, 1938 (April 17, 1937); see *Ceram. Abs.*, **16** [11] 337 (1937). G.M.H.

Heat-absorbing glass. JENAER GLASWERK SCHOTT & GEN. Ger. 651,688, Sept. 30, 1937 (July 13, 1936); J 55,520, VI/32*b*, Gp. 2; *Jour. Soc. Glass Tech.*, **22** [89] A13

(1938).—Heat-absorbing glass of the type described in Ger. 604,146 (*Ceram. Abs.*, **14** [6] 139 (1935)) contains, in addition to the materials specified, the oxides of antimony and lead.

Hollow glass blocks. OWENS-ILLINOIS GLASS CO. Brit. 484,173, May 11, 1938 (Sept. 11, 1936).

Insulator. J. T. LITTLETON (Corning Glass Works). U. S. 2,118,795, May 24, 1938 (Sept. 21, 1931).

Machine for the manufacture of glass articles. BRITISH BOTTLES, LTD., AND S. HUNT. Brit. 485,387, June 1, 1938 (Nov. 23, 1936).

Machine for manufacturing glass bottles, etc. W. E. EVANS (F. O'Neill). Brit. 485,370 and 485,451, June 1, 1938 (Nov. 14, 1936).

Making articles of vitreous material. GAMES SLAYTER (Owens-Illinois Glass Co.). U. S. 2,119,259, May 31, 1938 (June 15, 1932; renewed Oct. 27, 1937). The method comprises sealing an air bubble in a mass of vitreous material while the latter is in a plastic condition, reducing the pressure on the entire exterior surface of the mass and thereby permitting the latter to be expanded by the internal pressure of the sealed air, and molding the mass to a predetermined shape simultaneously with the expansion.

Making glass dropping flasks. CARL SCHNUERLE. Ger. 654,855, Dec. 31, 1937; Cl. 32*a*. 15; *Chem. Abs.*, **32**, 3568 (1938).—Method and apparatus are described.

Making and joining glass building blocks. CORNING GLASS WORKS. Brit. 484,560, May 18, 1938 (April 22, 1937); addition to 439,401, Dec. 18, 1935.

Manufacture of compound glass. A. KÄMPFER. Ger. 659,988, April 13, 1935; Cl. 39*b*. 27; *Chem.-Ztg.*, **62** [35] 311 (1938). D.A.B.

Manufacture of glass blocks. OWENS-ILLINOIS GLASS CO. Brit. 484,174, May 11, 1938 (Oct. 31, 1936).

Manufacture of glass for illuminating purposes. J. MEISSNER GLASRAFFINERIE, G.M.B.H. Ger. 654,431, July 4, 1936; Cl. 75*d*. 2; *Chem.-Ztg.*, **61** [99] 975 (1937). D.A.B.

Manufacture of optical glass. SENDLINGER OPTISCHE GLASWERKE GES. Brit. 484,587, May 18, 1938 (Nov. 7, 1935).

Means and method for treating glass. H. H. BLAU AND K. K. KNAELL (Corning Glass Works). U. S. 2,119,949, June 7, 1938 (June 8, 1936; renewed May 5, 1938). A glassmelting tank comprises bottom and side walls built up at least in part of relatively thin cast refractory blocks having high thermal conductivity, means associated with the blocks for controlling heat flow through them, baffles in the tank mechanically controlling and directing flow of the glass in the tank, the baffles being formed of relatively thin cast refractory blocks having high thermal conductivity, and means associated with the baffles for convectionally effecting and controlling the flow of glass about the baffles.

Melting off caps from hollow glassware. A. MEDER. Ger. 651,260, Sept. 23, 1937 (March 26, 1932); B 154,985, VI/32*a*, Gp. 27; *Jour. Soc. Glass Tech.*, **22** [89] A37 (1938).—The two sides are drawn apart by tension applied to each so that the thinned section remains in the zone of the burner for finishing the edge after separation.

Metal or glass plates with small holes. BERNHARD WEMPE. Fr. 820,762, Nov. 18, 1937; *Chem. Abs.*, **32**, 3568 (1938).—Thin sheets of glass or metal with small holes, *e.g.*, for use as spinning nozzles, are made by placing sheets of glass or metal one above the other with parallel wires placed between the successive sheets, heating the sheets under pressure until the whole becomes plastic and forms a homogeneous mass, cooling the mass, and cutting it in slices perpendicular to the direction of the wires. The small pieces of wire may be removed by acid.

Method and apparatus for making glass. P. G. WILLETTS (Hartford-Empire Co.). U. S. 2,118,799, May 24, 1938 (Nov. 13, 1936).

Molten glass feeding method and apparatus. T. F. PEARSON (Crown Cork & Seal Co., Inc.). Can. 373,889, May 24, 1938 (April 17, 1935). G.M.H.

Process for the purification of silica. ROBERT HUTCHINSON AND J. A. NEWBOLD. U. S. 2,119,105, May 31, 1938 (Dec. 16, 1935). The method of purifying sand to render it fit for the manufacture of colorless glass comprises partially filling a closed vessel with dilute sulfuric acid, adding to the solution both the sand and a substance which is chosen from the group consisting of zinc, oxalic acid, formic acid, sodium formate, and potassium ferrocyanide, which substance in combination with sulfuric acid evolves a gas which reduces ferric sulfate, heating the vessel, and finally washing the sand after the vessel has been opened until the sand has been purified.

Protective glass. DEGEA A.-G. (Auerges.). Fr. 816,383, Aug. 6, 1937; *Chem. Abs.*, **32**, 1889 (1938). See Brit. 466,262, June 9, 1937.

Regulating temperature of glass stream feeding sheet glass rolls. SOC. ANON. DES MANUFACTURES DES GLACES & PRODUITS CHIMIQUES DE ST. GOBAIN, CHAUNY & CIREY. Ger. 653,494, Nov. 11, 1937 (Oct. 16, 1935); S 120,131, VI/32*a*, Gp. 19; *Jour. Soc. Glass Tech.*, **22** [89] A26 (1938).—In a method of feeding glass to rolls in which, of a number of zones into which the stream can be divided, only that next the furnace is covered over, means are provided for regulating the temperature of the stream in each of the various zones.

Repairing glassmelting furnaces. DIDIER-WERKE A.-G. Ger. 653,493, Nov. 25, 1937; Cl. 32*a*. 1; *Chem. Abs.*, **32**, 2307 (1938).—In repairing tank furnaces for melting glass by inserting preheated brick into the furnace wall during the operation of the furnace, the brick are preheated in such a manner that their inner surfaces (the surfaces which are to form the inner face of the furnace wall) are hotter than their outer surfaces. Methods of procedure are indicated.

Safety glass. CHEMISCHE FORSCHUNGSGES. M.B.H. Ger. 652,978, Nov. 11, 1937; Cl. 39*b*. 27; *Chem. Abs.*, **32**, 1420 (1938).—Nonsplintering glass is made by pressing glass plates with an intermediate layer of a mixture of alkyl cellulose ether and more than 50% of natural resin. The preferred proportions are 1 of cellulose ether to 3 of resin. Examples are given.

Suction forming machines. DEUTSCHER VERBAND DER FLASCHENFABRIKEN G.M.B.H. Ger. 652,661, Oct. 21, 1937 (Dec. 4, 1935); M 132,823, VI/32*a*, Gp. 13; *Jour. Soc. Glass Tech.*, **22** [89] A35 (1938).—Two degrees of vacuum, one applied to the neck ring and the other to the joints in the blank molds, are provided for.

Tempered glass objects. PILKINGTON BROS., LTD.

Fr. 815,725, July 21, 1937; *Chem. Abs.*, **32,** 1888 (1938).—Objects having variations in thickness or of complex form which have been heated and quickly cooled to temper the glass are heated for a suitable time to a temperature at which the glass is capable of relaxing the higher tensions while not relaxing, or only slightly, the lower tensions.

Tempering glass articles. J. B. MITFORD (Pilkington Bros., Ltd.). Ger. 660,346, Jan. 3, 1937; Cl. 32*a*. 30; *Chem.-Ztg.*, **61** [98] 965 (1937). D.A.B.

Thermal treatment of glass. CORNING GLASS WORKS. Fr. 817,557, Sept. 6, 1937; *Chem. Abs.*, **32,** 2308 (1938).—Glass objects are tempered to a high degree and then subjected to a thermal treatment at a temperature appreciably below the tension point of the glass to reduce the tempering to a desired degree.

Transparent vitreous compositions. COMPAGNIE FRANÇAISE POUR L'EXPLOITATION DES PROCÉDÉS THOMSON-HOUSTON. Fr. 821,794, Dec. 13, 1937; *Chem. Abs.*, **32,** 3927 (1938).—Glasses containing SiO_2 52 to 64, B_2O_3 29 to 40, Na_2O 2 to 7, and Al_2O_3 0 to 5% may be sealed without tension to alloys containing Ni 39 to 44, Co up to 7, Mn up to 0.5, and Si up to 0.5%. They may be used in making electrical apparatus.

Vacuum jacketed glass tube and shape. N. M. ELIAS. U. S. 2,119,009, May 31, 1938 (June 27, 1935).

Vacuum-tight ceramic bodies suitable for sealing to soft glass. GENERAL ELECTRIC CO., LTD. (Patent-Treuhand Ges. für elektrische Glühlampen). Brit. 484,615, May 18, 1938 (Jan. 20, 1937).

Vitreous article coloring process. ORMOND H. PADDOCK AND ARTHUR M. GREAVES-WALKER (American Securit Co.). Can. 370,967, Jan. 4, 1938 (Feb. 15, 1937; in U. S., Feb. 21, 1936). A process in the manufacture of tempered glass sheets comprises heating the sheet for a predetermined time at a predetermined temperature followed by sudden cooling so that if broken the sheet will disintegrate into small relatively harmless particles; the method of surface coloring the sheet during the tempering period consists of applying to the surface a colored vitrifiable material, heating the sheet, preliminary to cooling, to a temperature above its softening point, and fusing the colored material to it. The colored vitrifiable material has as one of its components pulverized glass having a fusion point lower than that of the tempered glass sheet and substantially the same coefficient of expansion and contraction and being of such character that it will be properly fired upon the sheet without affecting the breaking pattern of the sheet. The article so produced is also covered. G.M.H.

Wired-glass substitute. CHEMISCHE FORSCHUNGSGES. M.B.H. (Willy O. Herrmann, inventor). Ger. 651,175, Oct. 8, 1937; Cl. 39*a*. 17.03; *Chem. Abs.*, **32,** 1420 (1938).—Wire fabric used in the manufacture of wired glass is replaced by a fabric made from filaments of polyvinyl alcohol, or by a mixed fabric having a warp of wire and a weft of polyvinyl alcohol filaments.

Structural Clay Products

Calcium silicate cements with special reference to sand-lime brick. H. COURTNEY BRYSON. *Sands, Clays & Minerals*, **3** [3] 251–57 (1938).—A table gives the strengths for different mixtures of fat and hydraulic lime with sand. The historical development of manufacturing processes is outlined. Three grades of brick are employed: (1) for interior walls, crushing at 1000 lb./sq. in., (2) for external walls, crushing at 2000 lb./sq. in., and (3) engineering brick, crushing at 2800 lb./sq. in. Instead of sand, blast-furnace slag rich in silica is used with advantage in several European countries. M.H.

Tests at the Bureau of Standards on the permeability of masonry walls. D. E. PARSONS. *Amer. Builder*, p. 76 (Sept., 1937).—P. suggests a method of laying brick to avoid leaks. One hundred thirteen walls, 50 in. high, 40 in. long, and from 4 to 12 in. thick were tested. Three kinds of brick, five kinds of mortar, four types of workmanship, and a number of different designs were used. The results showed that workmanship was the most important item, the kind of mortar was a consideration, the kind of joints was important, and tooling of the mortar face was necessary to prevent leaks. Details of tests and the results of each test are given. G.L.S.

PATENTS

Brick cutting machine. HUGO FILIPPI (Illinois Brick Co.). U. S. 2,118,552, May 24, 1938 (March 12, 1937).

Cellular clay products. CELLULAR CLAY CORP. Ger. 657,157, Feb. 25, 1938; Cl. 80*b*. 18.02; *Chem. Abs.*, **32,** 3928 (1938).—Finely ground calcined clay is mixed with a dry substance capable of liberating a gas, *e.g.*, dolomite, and the mixture is made plastic by addition of dilute acid, *e.g.*, H_2SO_4 or HCl of 3% concentration. The mixture is then molded, allowed to dry, and fired.

Fireproof building material. V. M. GOLDSCHMIDT. Ger. 659,218, May 19, 1935; Cl. 80*b*. 8.14; *Chem.-Ztg.*, **61** [98] 965 (1937). D.A.B.

Manufacture of heat- and sound-insulating materials from peat. K. BRAMMING AND W. HENRIKSEN. Brit. 477,919, Jan. 19, 1938 (July 13, 1936).

Tile. A. J. STREAT. U. S. 2,118,744, May 24, 1938 (Jan. 10, 1938). A building tile comprises spaced wall sections of any desired height and width, and top and bottom connecting webs forming longitudinal grooves at the top and bottom of the tile, the top web being provided at one side of the tile with a finger-grip extension extending upwardly and inwardly above the top groove and having a lower approximately hook-shaped finger-receiving surface overhanging the dead center of the tile and adapted to enable the tile to be lifted and handled solely by the fingers of one hand, the finger-grip extension projecting above the top of the tile sufficiently to extend above the joint between two superposed tile and form a water break to prevent water from working from the outer side of the tile to the inner side thereof.

Wall structure. ANDREW MALINOVSZKY. U. S. 2,118,936, May 31, 1938 (Sept. 7, 1937).

Refractories

Action of fuel-oil ash on refractory linings. G. V. *Argile*, No. 182, pp. 11–15 (1938).—V. discusses the attack of refractory linings by fuel-oil ash in boiler furnaces and other types. The composition of fuel-oil ash which is used in the Navy is 70% soluble sulfates of sodium, potassium, and magnesium, 9% vanadium, 1% nickel, 6% lime, and traces of Fe_2O_3 and MgO. The alkaline compounds of vanadium are very corrosive and greatly injure silicoaluminous refractories. Fuel oil of Persian origin contains up to 5% vanadium pentoxide, while that from Oklahoma contains up to 22.5%. The refractories should possess the greatest possible density and a suitable granulometric composition, should undergo severe firing to promote transformation, and should have a low expansion. Dispersed graphite can be used in some cases as a protective lining; fused mullite, however, is the best solution. The arrangement of the burners and of the combustion chamber is also important. M.V.C.

Alumina and titania in clays. R. V. Rodt. *Feuerungstechnik*, **26**, 10–12 (1938).—The presence of titania reduces the refractoriness and the refractoriness under load of clays; thus, it is necessary to know the titania content before any classification of properties based on chemical composition, *e.g.*, on % Al_2O_3, is attempted. E.P.

Attack of coal slags on refractory brick. R. Fehling. *Feuerungstechnik*, **26**, 33–35 (1938).—F. states the physical conditions of the problem and the dependence of the extent of reaction on the viscosity of the slag, the diffusion velocity in the reacted layer, temperature, and the character and properties of the brick. E.P.

Changes and destruction of blast-furnace brick in service. D. P. Zegzhda. *Ogneupory*, **5** [7] 449–58 (1937).—The greatest destruction of the refractory lining occurs in the upper part of the shaft. The destruction of the refractories in the lower part of the furnace is promoted by gaseous reagents, such as CO and zinc vapors, besides mechanical causes. The penetration of zinc and carbon into the pores of the refractory greatly lowers the resistance of the brick. To increase the life of the refractory, brick used in the upper part of the furnace should possess greater resistance to pressure and wear while those used in the lower part should be more dense. M.V.C.

Development of a slagging test for refractories. H. M. Kraner. *Metals & Alloys*, 9 [4] 79–83 (1938).—Although the consumer has available the panel spalling test for determining heat shock resistance and the hot load test for resistance to loading at high temperatures, no standard test has been established for the ability to withstand chemical action. K. reviews the best tests suggested for the last property. The basic conditions that must be controlled in a universal slagging test are temperature or temperature cycle involved and its uniform application to all test pieces, atmospheric (oxidizing or reducing) uniformity, proper slag composition, viscosity of slag during the entire test, rate of slag application and drainage, and rate of flow of combustion gases past the test specimen during the test. F.P.P.

Effect of fluxes on the underload strength of a fire clay. J. F. Hyslop and J. McNab. *Trans. Ceram. Soc.*, **37** [4] 168–69 (1938); see *Ceram. Abs.*, **17** [5] 186 (1938). R.A.H.

Effect of hydrocarbon gases on refractory materials: I. E. Rowden and A. T. Green. Reprinted in *Trans. Ceram. Soc.*, **37** [3] 75–99 (1938); see *Ceram. Abs.*, **15** [10] 301 (1936). R.A.H.

Fundamentals of the Turkish iron and steel industry. B. Granigg. *Stahl & Eisen*, **57**, 833–38 (1937).—G. gives a survey of natural resources, including refractory materials. Quartzite, amorphous quartz, and chromite are abundant. The locations and extent of ore deposits are given. L.R.B.

Fused magnesia crucibles. E. P. Barrett and W. F. Holbrook. *Ind. Eng. Chem., Anal. Ed.*, **10** [2] 91–93 (1938).—The influence of furnace pressure, method of heat application, and impurities upon the melting point of magnesium oxide are described. Magnesium oxide heated under reduced pressure (0.5 to 1.0 cm. of mercury) volatilizes completely before it melts. When heated at atmospheric pressure in contact with carbon, magnesium oxide volatilizes rapidly at temperatures above 2000°C. Fused magnesia crucibles fired to approximately 2600°C tend to bulge at the base, indicating that there is a region of crucible flow at high temperatures rather than a sudden melting down. Processes for the manufacture of magnesia crucibles are reviewed in detail. The resistance of some of the resulting products to high-temperature chemical reactions is discussed. An improved method for the manufacture of magnesia crucibles is described, whereby the fused magnesia in suitable grain sizes is packed in specially designed molds by means of an electric vibrator. The molds and cores are easily machined from graphite electrodes. The crucibles are easily and rapidly formed without the use of binders and have a dense uniform structure. Both the graphite mold and the magnesia crucible may be dried rapidly and placed in a red-hot furnace without injury to the refractory crucible, and they can both be removed from a hot furnace without damage to the crucible. After firing to 1700°C, a shrinkage of about 0.125 in. in diameter is experienced in a magnesia crucible which was 2.5 in. in diameter when formed. Because of this shrinkage, the fired crucible may be readily removed from the graphite mold in which it was formed. This makes possible the re-use of the molds for forming additional crucibles. Illustrated. F.G.H.

High-grade refractory aluminous materials. G. Malquori, V. Sollago, and F. Sasso. *Ricerca Sci.*, [2] **8**, II [5–6] 299–315 (1937); *Chem. Zentr.*, **1938**, i, 2936.—The refractoriness of 16 different refractory bodies of Italian origin, containing from 17 to 69% Al_2O_3, was studied; their resistance to the corrosive effect of slag and sudden fluctuations of temperature was determined also. The good qualities of bodies with a mullite base were confirmed. The Al_2O_3 content of the body does not determine its technical properties; these properties depend to a much greater extent on the methods of working of the mix. M.V.C.

Insulation of furnaces lined with silica brick. R. Leduc. *Rev. Matériaux Construction Trav. Publics*, No. 340, p. 9B (1938).—By using highly refractory insulating materials, it is possible to lower the consumption of fuel and lengthen the life of refractories. Such insulation, however, requires a stricter supervision of temperatures. M.V.C.

Measurement of thermal conductivity of insulating material encased in sheet metal. I. S. CAMMERER. *Wärme*, **60**, 765–67 (1937); *Brit. Chem. & Phys. Abs.–B*, **57** [4] 327 (1938).—C. discusses difficulties involved in the measurement *in situ* of the *k* of lagging material, *e.g.*, on steam piping covered by metal sheathing. Tests showed that the differences in the emissivities of dull, polished, and painted sheathings seriously affect the results obtained when using a heat-flow meter of the thermocouple type. Errors may be minimized by wrapping the casing with thin paper in the vicinity of the flow meter.

Mullite refractory products. M. LÉPINGLE. *Ind. Chim. Belge*, **9** [4] 139–50 (1938).—Much care should be taken in preparing the grog to avoid after expansion of the shape when in use. The success in manufacturing mullite products depends mostly on the properties of the bond. L. describes a series of tests carried out and gives the results. See "Testing—," *Ceram. Abs.*, **16** [3] 92 (1937). R.W.D.

Physicochemical changes in fire brick during its use in coke ovens. R. N. GOLOVATYI. *Koks & Khim.*, No. 3, pp. 57–59 (1937); *Brit. Chem. & Phys. Abs.–B*, **57** [3] 243 (1938).—Four zones are found in used fire brick, due to the action of pyrolysis products on the inner surface and of combustion products on the outer surface. The SiO_2 content rises and the Al, Mg, Ca, and S contents of the brick fall from the inner to the outer surface; the C content is greatest in the middle zone. The relative thickness of the zones depends on the porosity of the brick. Quartzite is practically absent from the first zone, being replaced by tridymite and cristobalite. See "Chemical—," *Ceram. Abs.*, **15** [1] 21 (1936).

Production of magnesite brick by the water-vapor treating method. Z. YA. TABAKOV, V. V. BELOVODSKIĬ, E. O. KORTT, AND A. V. DRAZHNIKOVA. *Ogneupory*, **3** [11] 811–24 (1935).—High-quality brick may be obtained by hydration of the active oxides of calcium and magnesium with steam. By this method, brick with a higher lime content (up to 5%) are obtained. The steam treatment promotes the formation of a more homogeneous mix with respect to moisture and degree of hydration. M.V.C.

Refractories in the steel foundry. ANON. *Edgar Allen News*, **16** [192] 177–79 (1938).—Properties and fields of application are described. M.H.

Refractory furnace linings for the melting of nonferrous metals. Y. LETORT. *Bull. Assn. Tech. Fonderie*, **11** [11] 458–59 (1937); *Bull. Brit. Non-Ferrous Metals Research Assn.*, No. 108, p. 110 (1938).—L. gives brief notes on types of refractories to be used for the various alloys (heavy and light).

Refractory products containing silica and alumina manufactured from Italian raw materials. FELICE DE CARLI AND NELLO COLLARI. *Ricerca Sci.*, [2] **8, II** [5–6] 316–22 (1937); abstracted in *Chem. Zentr.*, **1938, i**, 2936.—Two refractory products manufactured from Sardinian raw materials and containing from 66.56 to 62.71% SiO_2 and from 30.03 to 34.29% Al_2O_3 were tested with regard to refractoriness, resistance to sudden variations of temperature, deformation under load at high temperature, porosity, resistance to pressure, permanent deformation at 1500°, and resistance to corrosion; the data obtained were compared with those of foreign refractories. The characteristics of Italian products are similar to those of foreign make with the exception of sagging at 1500°. M.V.C.

Silica brick. ETIENNE KONDOR. *Rev. Matériaux Construction Trav. Publics*, No. 340, pp. 1–6B (1938).—K. reviews the present methods of manufacture, raw materials used, and characteristics of silica brick. A bibliography is given. M.V.C.

Testing and properties of heat-insulating materials. A. H. JAY AND L. LEE. *Trans. Ceram. Soc.*, **37** [4] 151–67 (1938); see *Ceram. Abs.*, **17** [4] 145 (1938). R.A.H.

Thermal-conductivity coefficients of heat-insulating and refractory materials. A. AUBERT. *Chaleur & Ind.*, **18**, 87–90 (1937); *Chem. Abs.*, **32**, 3926 (1938).—Published data are summarized.

Use of pressed dolomite brick in the open-hearth furnace. J. SITTARD. *Stahl & Eisen*, **57**, 1305–1306 (1937).—Dolomite brick were formerly pressed at 350 to 400 atm. and mixed with 8 to 10% tar; they were attacked by the atmosphere, however, and could not be shipped. By trial, a satisfactory brick was developed made from fired grains (1 to 2 mm.); it was mixed with 4% tar, pressed at 2000 atm., and had a specific gravity of 2.8. To hinder the action of the atmosphere, the brick were coated with a tar-goudron mixture and wrapped in paper similarly treated. Used in the backwall of an open-hearth furnace (150 tons), these brick lasted for at least 25,000 tons of steel, being more economical than magnesite and chrome brick. A used brick was very hard and had a softening point of t_a = 1750° and t_e = 1900°C. These sintered brick disintegrated in ten days in the laboratory. L.R.B.

BULLETIN

Secondary expansion in refractory clays. J. O. EVERHART. *Ohio State Univ. Eng. Expt. Sta. Bull.*, No. 98, 23 pp. (1938); see *Jour. Amer. Ceram. Soc.*, **20** [11] 353–59 (1937). W.D.F.

PATENTS

Fused refractory. J. D. SULLIVAN (Battelle Memorial Institute). Can. 373,653, May 10, 1938 (March 4, 1937). G.M.H.

Heat-insulating slabs and method of making. BRITISH ZONOLITE PRODUCTS, LTD. Brit. 485,509, June 1, 1938 (March 27, 1936).

High-temperature furnaces. LÉON CHIFRINE. Fr. 817,470, Sept. 3, 1937; *Chem. Abs.*, **32**, 1985 (1938).—The brick used are coated during manufacture with a thin layer of Fe oxide or Fe oxide is added to the surfaces.

Making alumina and potassium sulfate. F. B. MACCARTHY (Olcott Payne). U. S. 2,119,551, June 7, 1938 (April 14, 1936). The method of treating potash alum by decomposing the aluminum sulfate portion of the potash alum by heating crystallized alum in admixture with a pulverulent to granular material selected from the group consisting of alumina and potassium sulfate and mixtures of them and burned alum, and continuing the heating sufficiently to decompose a large part at least of the aluminum sulfate component of the alum, and thereafter leaching at least a part of the calcined product.

Manufacture of lightweight mineral material. BRITISH ZONOLITE PRODUCTS, LTD. Brit. 485,512, June 1, 1938 (March 27, 1936).

Manufacture of magnesia. O. KIPPE AND KLÖCKNER-WERKE, A.-G. Ger. 654,114, Sept. 22, 1935; Cl. 80*b*. 8.01; *Chem.-Ztg.*, **61** [99] 975 (1937). D.A.B.

Manufacture of plastic brick, blocks, slabs, tile, etc. BRITISH ZONOLITE PRODUCTS, LTD. (F. E. Schundler & Co., Inc.). Brit. 485,511, June 1, 1938 (March 17, 1937).

Plastic refractory materials and processes for producing. BRITISH ZONOLITE PRODUCTS, LTD. (F. E. Schundler & Co., Inc.). Brit. 485,508, June 1, 1938 (March 17, 1937).

Refractory. H. C. FISHER (Norton Co.). U. S. 2,118,-789, May 24, 1938 (Sept. 27, 1935). A refractory mixture comprises a molded body composed of the following materials in substantially the proportions stated by weight: 95 silicon carbide grains, 2 bentonite, $2^1/_2$ Goulac, and 0.5% ferric oxide.

Refractory. C. W. SAXE (Norton Co.). U. S. 2,118,-798, May 24, 1938 (Sept. 27, 1935). A method of producing a porous refractory of high refractory qualities comprises selecting graded sizes of relatively pure fused alumina, mixing them together and with a small amount of alumina of microcrystalline structure, adding bentonite of the order of 3% or less, forming, and firing.

Refractory block and structure. M. C. NEIL. U. S. 2,120,000, June 7, 1938 (July 31, 1936). A refractory block for furnaces, etc., includes an outside face portion, an inside face portion, and a connecting spacer portion between the two portions of substantially smaller cross section than either.

Refractory material. R. C. BENNER AND H. N. BAUMANN, JR. (Carborundum Co.). U. S. 2,118,143, May 24, 1938 (April 25, 1935). The method of making refractory material comprises melting a mixture consisting of 10 to 35% boric oxide and 65 to 90% aluminum oxide, cooling the molten mixture, and causing the formation of a substantial proportion of boroaluminate crystals in the cooled body.

Refractory material. CARBORUNDUM CO. Ger. 655,-574, Jan. 19, 1938; Cl. 80*b*. 8.17; *Chem. Abs.*, **32**, 3928 (1938).—Material for making glass furnaces, etc., is made by pouring fused Al_2O_3 into a mold and congealing under conditions such that the product is mainly β Al_2O_3; 1 to 10% of alkali or alkaline earth may be added to the fused mass.

Refractory material. J. D. SULLIVAN (Battelle Memorial Institute). Can. 373,654, May 10, 1938 (March 8, 1937). G.M.H.

Refractory products. MAGNESITAL G.M.B.H. (Erich H. Martin, inventor). Ger. 657,156, March 3, 1938; Cl. 80*b*. 8.01; *Chem. Abs.*, **32**, 3928 (1938).—Refractory brick and other products fast to chilling are made by molding and firing a mixture of coarse sintered or fused MgO, containing not more than 2% of Fe_2O_3, with finely divided sintered or fused MgO containing at least 4% of Fe_2O_3. The coarse MgO should have a granule size of 2 to 6 mm. and should constitute 35 to 75%, preferably 50 to 70%, of the mixture. Products which become relatively soft under high pressure are obtained if the coarse MgO contains less than 4% of SiO_2. An example is given.

Synthetic corundum refractory. T. S. CURTIS (Aluminum Co. of America). Can. 373,478, May 3, 1938 (March 25, 1937). G.M.H.

Tile or brick for use in furnaces. E. H. HUTCHINSON AND E. J. & J. PEARSON, LTD. Brit. 485,037, May 25, 1938 (Feb. 27, 1937).

Terra Cotta

Ceramic products in modern industrial plant construction. ANON. *Architectural Forum*, pp. 133–36 (Feb., 1938).—The use of porcelain enamel, glass, tile, Kittanning brick, and glass-lined tanks in the new Campana factory at Batavia, Ill., is illustrated. G.L.S.

Ceramics in the new Kansas City auditorium. ANON. *Architectural Forum*, pp. 216–28 (March, 1937).—Photos show special lighting fixtures and the use of terra cotta walls. G.L.S.

Decoration of stoneware. ANON. *Keram. Rundschau*, **45** [37] 419–20; [38] 435–37 (1937).—The following processes are discussed: colored paste, engobe, underglaze and overglaze decoration, colored glazes, and artistic ceramic. The preparation of colors for different purposes is described in detail. F.E.V.

Effect of different bodies on some wetting and flow characteristics of glazes. C. MAJOR LAMPMAN. *Jour. Amer. Ceram. Soc.*, **21** [7] 252–58 (1938).

Errors in stoneware manufacture. W. BACHER. *Keram. Rundschau*, **45** [30] 333–35; [31] 347–49; [33] 372–73 (1937).—B. describes the principal errors in the preparation of clay pastes during turning, slip-casting, first firing, decorating, glazing, and glaze firing. The treatment of saggers is dealt with. F.E.V.

Floor tile manufacture. L. TONTSCHEFF. *Keram. Rundschau*, **45** [32] 357–61 (1937).—The raw material is a plastic clay with a low sintering point; its softening point is at least 5 cones higher. T. describes the manufacture of the paste, pressing, drying, firing, and sorting. Particulars are given concerning heated presses, manufacture of black floor tile by smoke and iron reduction, and defects and their correction. F.E.V.

PATENTS

Manufacture of a colored paving material suitable for athletic and pleasure grounds. W. DREWES. Ger. 654,-101, June 17, 1936; Cl. 80*b*. 19.03; *Chem.-Ztg.*, **61** [99] 975 (1937). D.A.B.

Manufacture of glazed and impervious ceramic products. C. GROVEN. Ger. 654,500, March 29, 1935; Cl. 80*b*. 12.05; *Chem.-Ztg.*, **61** [99] 975 (1937). Addition to Ger. 582,329. D.A.B.

Treatment of plastic materials for producing brick, tile, etc. E. B. JONES. Brit. 484,154, May 11, 1938 (Oct. 28, 1936); addition to 445,216, April 22, 1936.

Whiteware

Firing hard porcelain and other ceramic products. MARC LARCHEVÊQUE. *Céramique*, **41** [599] 17–30; [600] 37–46 (1938).—L. discusses defects in ceramic products due to raw materials and firing, the causes of gaseous liberations which produce blisters, bubbles, cracks, etc., and certain defects due to the characteristics of furnace gases which produce yellow (oxidation) or black (ultra-reduction) coloring of the ware. Necessity of analysis of

raw materials and, notably, of gases which may arise from raw materials is emphasized because even infinitesimal amounts of impurities may produce some of the defects. Phosphates, calcium carbonate, presence of silicates, additions of alkalis, furnace ashes, and contact with the silicon carbide lining were studied with respect to their effect, and defects due to their presence or use are discussed. M.V.C.

Life history of a glaze: I, Maturing of a whiteware glaze. II, Measurement of stress in a cooling glaze. A. M. BLAKELY. *Jour. Amer. Ceram. Soc.*, **21** [7] 239–51 (1938).

Manufacture of porcelain insulators. M. REITZ. *Keram. Rundschau*, **45** [36] 407–10 (1937).—R. describes the raw materials and the manufacturing process. The ceramic body contains 43.0 clay substance, 30.6 quartz, and 26.4 feldspar, the total shrinkage being 17%. The glaze contains 0.3 K_2O + 0.7 CaO, 0.5 Al_2O_3, and 4.0 SiO_2. The laboratory and practical tests are outlined. Difficulties in drying and roughing are described. F.E.V.

Use of Hagendorf feldspar in glaze for porcelain. O. REUMANN. *Keram. Rundschau*, **45** [48] 553–57 (1937).—R. tested glazes of Norwegian or Hagendorf feldspar to determine their melting point, shrinkage, flow, crazing, gloss and its aspects, susceptibility to smoke, influence on underglaze colors, and resistance to abrasion. The German raw material lowers the melting point by $^1/_2$ cone and reduces the gloss of glazes with high feldspar contents; other properties are unchanged. F.E.V.

BOOK

Manufacture of Porcelain. Practical Experience (Die Herstellung des Porzellans. Erfahrungen aus dem Betrieb). HANS HEGEMANN. Enlarged edition by F. Dettmar. Chem. Laboratorium für Tonindustrie, Berlin, 1938. 386 pp., 243 illustrations. Price 26 Rm. Chapter subjects are as follows: raw materials, their compositions, preparation, and testing, and composition of white and colored porcelain bodies, magnesia bodies, and other specialties; glazes, colors, and metallizing processes; manufacturing methods, such as throwing, casting, turning, etc.; common defects in manufacture and firing stages; drying and firing problems; grinding and polishing operations; and the testing of finished products. The entire field of porcelain manufacture is covered. Illustrated. L.E.THIESS

PATENTS

Ceramic composition. H. M. KRANER (Feldspathic Research Corp.). Can. 373,532, May 3, 1938 (March 2, 1937). This raw ceramic dry-press batch comprises constituent material including pyrophyllite and has an average hardness less than that of a steel die. G.M.H.

Ceramic materials. KARL SCHUSTERIUS. Fr. 816,900, Aug. 19, 1937; *Chem. Abs.*, **32**, 2308 (1938).—Ceramic materials, particularly for use as dielectrics, composed principally of TiO_2 contain also oxides of Cd and (or) Bi. Oxides of Zr, Th, and Zn may also be present. An example contains TiO_2 60, ZrO_2 35, and CdO 5%.

Metal coating for ceramic bodies. RAY HIGGINS. U. S. 2,119,989, June 7, 1938 (Aug. 13, 1937). (1) The method of metallizing the surface of a ceramic body comprises the steps of applying to the surface a base coating comprising a suitable bonding material and a fine aggregate of highly refractory material of greater strength than the material of the body, firing the body and coating, and thereafter applying a coating of metal over the surface of the base coating, the particles of the aggregate being sufficiently refractory to retain their separate identities at the firing temperature for the ceramic body so as to produce a rough surface to receive the metal coating. (13) The combination, with a ceramic body, of a surface coating therefor comprises a base layer of a different inorganic refractory material from that of the ceramic body, the base layer being bonded to the surface of the ceramic body and having depressions and projections on the surface thereof of suitable size and spacing to provide firm anchorage for a coating of metal, and a metal coating on the surface of the base layer and anchored thereto by the projections and depressions, the metal coating being of sufficient thickness to fill all of the depressions and overlie the projections of the base layer.

Spark plug. W. P. INNES, JR. Can. 373,603, May 3, 1938 (March 16, 1937). PHILIP REDINGER, JR. Can. 373,741, May 10, 1938 (April 1, 1937; in U. S., April 22, 1936). C. A. XARDELL. Can. 373,628, May 3, 1938 (June 3, 1937). G.M.H.

Equipment and Apparatus

Apparatus for examining strains in glass. POLAROID PRODUCTS, LTD. *Jour. Sci. Instruments*, **15** [4] 142–43 (1938).—The Labscope, a portable polarizing strain tester, uses Polaroid in place of nicol prisms for polarizer and analyzer. Illustrated. J.L.G.

Apparatus for measuring p_H by color wedges. A. GALLENKAMP & CO., LTD. *Jour. Sci. Instruments*, **15** [3] 112 (1938).—It is claimed that the Hellige wedge Pehameter gives readings accurate to 0.1 p_H by means of color wedges and indicator solutions. It is briefly described. Price £2 15s. Illustrated. J.L.G.

Apparatus for the microanalysis of gases. T. CARLTON SUTTON. *Jour. Sci. Instruments*, **15** [4] 133–35 (1938).—Illustrated by scale drawings. 23 references. J.L.G.

Apparatus for microscopic examination in polarized light. POLAROID PRODUCTS, LTD. *Jour. Sci. Instruments*, **15** [3] 112 (1938).—The device is 7 in. long and weighs only 2 lb. It should be satisfactory for preliminary observations and demonstrations at low magnifications in the field of minerals, textiles, ceramics, etc. Price £16 10s. Illustrated. J.L.G.

Average diameter of particles just passing the 325-mesh sieve. STEWART S. FRITTS. *Ind. Eng. Chem., Anal. Ed.*, **9** [4] 180–81 (1937).—In determining the specific surface in terms of square centimeters per gram, as given by the Wagner turbidimeter, it is generally assumed that the 325-mesh sieve separates the fraction at 60μ, although actually it has an aperture of 44μ. F. has applied Stokes'

law in so far as it pertains to the use of the Wagner turbidimeter. The data, presented from a new viewpoint, give additional experimental proof that the 325-mesh sieve separates at an average particle diameter of 45μ.
F.G.H.

Colloid milling with a ball mill. A. H. M. ANDREASEN, S. BERG, AND E. KJAER. *Kolloid-Z.*, **82** [1] 37–42 (1938).—Barite and colcothar were separately ground with very small steel balls in a laboratory mill. Data are given on the grain-size percentages of each after various grinding periods. F.P.P.

Coördination of theories of gravity separation. ARTHUR A. HIRST. *Trans. Inst. Mining Engrs.* [London], **94,** 93–113 (1937).—The laws of fluid resistance are developed. Free settling, hindered settling, and interlocking beds of particles are considered in relation to the resistance laws. A.H.E.

Determining grindability of substances. W. GRÜNDER. *Z. Ver. Deut. Ing., Beiheft Folge,* **1938,** No. 1, pp. 17–23; *Chem. Abs.*, **32,** 3672 (1938).—The "structure tester" is a cone mill coupled to an electrodynamometer. From a recorded power-time diagram the work necessary to grind a sample from a known initial screen analysis to a definite final size can be calculated. Figures, diagrams, experimental results, and 9 references are given.

Development of ceramic machines in the last 10 years. G. HELM. *Sprechsaal,* **71** [1] 2–5 (1938).—Machines used in working clay, shaping, glazing, and engobing are briefly discussed. Illustrated. M.V.C.

Drying at low pressures. JOSEF MATĚJKA. *Zprávy Československ. Keram. Společnosti,* **12,** 134–37 (1935); *Chem. Zentr.*, **1936, ii,** 1994; *Chem. Abs.*, **32,** 3925 (1938).—Raw materials of too-high plasticity when dried under normal conditions suffer small cracks or disintegration. On drying under reduced pressure (95 and 380 mm. Hg), usually with large shrinkage, satisfactory molded objects were obtained. The experiments indicated that not the shrinkage but rather irregularities in drying and strains developed during drying were responsible for cracks.

Drying materials in trays. Evaporation of surface moisture. C. B. SHEPHERD, C. HADLOCK, AND R. C. BREWER. *Ind. Eng. Chem.*, **30** [4] 388–97 (1938).—The tray drying of surface moisture from nonhygroscopic materials and the effects of various drying conditions on the constant drying rate were studied. Illustrated. F.G.H.

Effect of temperature and humidity on the rate of drying of clay shapes. H. H. MACEY. *Trans. Ceram. Soc.*, **37** [4] 131–50 (1938); see *Ceram. Abs.*, **17** [6] 225 (1938). R.A.H.

Electric furnace for automatic combustion in microelementary analysis. L. T. HALLETT. *Ind. Eng. Chem., Anal. Ed.*, **10** [2] 101–103 (1938).—As the combustion of the sample is automatic, the operator has more time to carry out calculations, titrations, and weighing. About 25% more work per day can be done than is possible when burning the sample by hand, and the operator is less fatigued. Illustrated. F.G.H.

Electrical power transmission in brick plants. W. KNIEL AND K. SPINGLER. *Tonind.-Ztg.*, **61** [72] 807–808; [73] 821–22 (1937).—Direct and alternating currents, the inherent properties of the corresponding types of generators and motors, and their suitability for the widely varying jobs in a clay plant are discussed. A large part is devoted to the problem of the power factor. 12 graphs. W.K.

Estimating life of electric heating elements. F. E. BASH. *Metal Progress,* **33** [2] 143–47 (1938).—Application of a standard method for testing the life of resistance wires for electrical heating to production control has greatly improved the durability of such alloy wires. It is now possible to estimate minimum life at operating temperatures from the test figures derived at much higher temperatures. The technique is being adapted to resistors of large diameters for heating large production-size furnaces. F.P.P.

Flow of water and compressed air in pipes. F. M. VAN DEVENTER. *Combustion,* **9** [5] 38–39 (1937).—Charts and formulas are given. H.E.S.

Fundamentals of drying and air conditioning. E. R. GILLILAND. *Ind. Eng. Chem.*, **30** [5] 506–14 (1938).—The basic equations for the rate of heat and mass transfer are reviewed. Illustrated. F.G.H.

Heat-resisting steels in industrial furnaces. P. ZACHAROV. *Sklářské Rozhledy,* **13,** 90–92 (1936).—Heat-resisting steels are classified as (1) chrome steels with a Cr content of 20 to 30%; (2) chrome-aluminium-silicon steels containing 8 to 30 Cr, 1 to 5 Al, and 2% Si; (3*a*) chrome-nickel steels containing 20 to 30 Cr and 5 to 25% Ni; and (3*b*) chrome-nickel steels containing 15 to 20 Cr and 40 to 60% Ni. Groups 1 and 2 were resistant to furnace gases containing sulfur. Heat-resisting steels have thermal conductivity coefficient values about 50% greater than those for normal steels. E.P.

Industrial grinding and mixing of loam, clay, and grog in brick plants using modern equipment. J. F. KESPER. *Ziegelwelt,* **68,** 280–81, 293–94 (1937); *Chem. Abs.*, **32,** 3565 (1938).—Types of wet and dry pans and pugmills are described.

Law of motion of particles in a fluid. R. T. HANCOCK. *Trans. Inst. Mining Engrs.* [London], **94,** 114–21 (1937).—Equations and a discussion of free and hindered settling are presented. A.H.E.

Lubricating oil for circulating systems of steam turbines. SOCONY-VACUUM OIL CO., INC. *Combustion,* **9** [6] 29–31 (1937).—The proper characteristics for steam turbine oils are presented. The viscosity requirements, chemical composition, resistance to oxidation and emulsion, and the degree of refining to produce the most suitable oil are discussed from a fundamental standpoint. H.E.S.

Machinery in the clay industry. BAUMEISTER. *Tonind.-Ztg.*, **61** [54] 597–98 (1937).—B. urges regular inspection and proper care of all moving parts of the clayworking machines, especially of the gears of roll crushers, bearings of augers, and bearings and mullers of wet and dry pans. W.K.

Measurement of stress in ceramic bodies. W. STEGER. *Keram. Rundschau,* **45** [41] 467–72 (1937).—Since 1928 S. has developed a method of measuring stress between a glaze and a ceramic body. He gives theoretical and practical information enabling the industrialist to use this process. The Mellor formula and the measurement and interpretation of data are explained in detail. The importance of the intermediate layer (between body and

glaze) is emphasized. See "Mathematical—," *Ceram. Abs.*, **15** [4] 127 (1936). F.E.V.

Mixing in exact proportions. ANON. *Tonind.-Ztg.*, **61** [71] 798–99 (1937).—Three arrangements for proportioning raw materials by weight or by volume are described. W.K.

Pan grinding. J. W. MELLOR. *Trans. Ceram. Soc.*, **37** [3] 126–29 (1938).—M. gives a mathematical analysis of the relation between number of revolutions per minute of runners and the diameter of pan. R.A.H.

Photoelastic polariscope. POLAROID PRODUCTS, LTD. *Jour. Sci. Instruments*, **15** [3] 111 (1938).—The apparatus determines stress in transparent bodies by the photoelastic method. Polaroid plates are available in diameters of $4^1/_4$, $6^1/_4$, and $8^1/_4$ in. Special sizes up to a diameter of 12 in. can be supplied. J.L.G.

Portable photoelectric illumination meter. J. S. PRESTON. *Jour. Sci. Instruments*, **15** [3] 102–105 (1938).—P. describes a photoelectric illumination meter which uses the emission type of photocell with valve amplification. Schematic circuit diagram and one photograph. J.L.G.

Precision powder camera for photographs at high temperatures and a measuring instrument for X-ray diagrams. F. SCHOSSBERGER. *Z. Krist.*, **98**, 259–65 (1938). H.I.

Precision recording dilatometer. R. A. ACKLEY AND F. M. WALTERS, JR. *Metals & Alloys*, **7** [12] 314–20 (1936).—An instrument is described that records automatically and simultaneously a differential dilatation-temperature curve, obtained photographically on a revolving drum, and a time-temperature curve drawn by a pen. The temperature coördinate is provided by driving the drum from a suppressed zero Micromax recording controller, and the dilatation coördinate is provided by optical lever amplification of the difference of expansion between a specimen and comparison pieces. The amplification of differential dilatation is 500; the temperature scale is 20 min./in. Specimen temperatures may be accurately controlled and maintained. The instrument, which is designed particularly for precise determinations of transformations in metals and alloys, may be used for temperatures between 25 and 1100°C and for differential length changes of 0.00005 to 0.01 in. F.P.P.

Sedimentograph. H. SAUER. *Kolloid-Z.*, **80** [3] 287–91 (1937).—S. describes an instrument for measuring the degree of fineness of substances in suspension. The measurement depends on the light absorption of the specimen as observed with a Pulfrich step-photometer. Suspensions of cement, heavy spar, and bentonite were examined. The instrument also yields data on the grain size of the particles in suspension. F.P.P.

Sensitive hydrometer for determining small amounts of clays or colloids in soils. G. J. BOUYOUCOS. *Bull. Amer. Ceram. Soc.*, **17** [6] 254 (1938); see *Ceram. Abs.*, **17** [1] 30 (1938).

Sixty-five mesh grinding in a closed circuit with stainless steel screens. WALTER M. STEPHEN. *Amer. Inst. Mining Met. Engrs. Tech. Pub.*, No. 901; *Mining Tech.*, **2** [3] 5 pp. (1938).—At the Copper Cliff concentrator, a set of three 4- x 5-ft. screens were operated in closed circuit with a $6^1/_2$- x $12^1/_2$-ft. Marcy rod mill, replacing a classifier. A common steel screen had to be replaced in 40 hr. Stainless steel screens tested up to one month's service showed no visible signs of wear. A 41- x 10-mesh screen gave the undersize most closely approaching the classifier. For equal tonnages, capital cost, repairs, and power consumption favor screens over classifiers, while labor costs are about equal. The screen product has a uniform assay throughout its range. This is advantageous at times, but when it is necessary to overgrind an ore, a classifier is more desirable. W.D.F.

Spectrograph in the iron foundry. H. B. VINCENT, R. A. SAWYER, AND A. M. SAMPSON. *Metals & Alloys*, **9** [2] 27–32 (1938).—A spectrographic technique is described by which a sample of cast iron may be analyzed in 8 min. elapsed time for Cr, Cu, Mn, Mo, Ni, and Si. In routine foundry use, the reliability of the analysis is better than that of the chemical laboratory previously used; production control and not simply inspection analysis is provided. F.P.P.

Thermostatical investigation of high-temperature drying. M. TAMURA. *Trans. Soc. Mech. Engrs.* [Japan], **2**, 138–48 (1936); *Brit. Chem. & Phys. Abs.–B*, **57** [4] 327 (1938).—Results on drying tests with unglazed ceramic spheres are recorded.

Trends in classification. C. K. MCARTHUR. *Amer. Inst. Mining Met. Engrs. Tech. Pub.*, No. 815; *Mining Tech.*, **1** [3] 8 pp. (1937).—The important question is not the circulating load carried but the total tonnage fed to the mill of original feed plus classifier product. In every grinding unit an effective volume through which feed will pass is available which, if properly utilized, will lead to increased capacity. Ball mills have been loaded to 30 tons/cu. ft./day by using a heavy-duty classifier; this decreased grinding costs and increased tonnage without additional floor space. To facilitate this, there are needed (1) a large diameter, reasonable length ball mill with large feed and outlet openings; (2) a mill feed scoop with the proper spirals and scoop lips that should dig and not drag; (3) a carefully designed classifier; and (4) a meter installed on the ball-mill motor to show overload or underload. W.D.F.

Use of photocells in dispersoid analysis. E. HOFFMAN. *Kolloid-Z.*, **79** [2] 154–55 (1937).—H. uses a photocell to determine the change, with passage of time, in the amount of light transmitted by a specific thickness of suspension during sedimentation, and from this, the dispersity of the suspension. F.P.P.

Vibration viscosimetry. R. AUERBACH. *Kolloid-Z.*, **82** [1] 24–25 (1938).—A. describes a method for determining the effect of vibration on the motion of suspensions such as cement or silica slurries. The viscosity was determined with a Wilhelm-Ostwald viscometer; vibration frequency was about 100/sec., and amplitude varied between 0 and 125 mm. The viscosity of cement and silica slurries decreased rapidly with increasing amplitude. The viscosity of dry sand increased with rising amplitude. F.P.P.

Viscosities of suspensions and solutions: VIII, Inertia effects of suspended spheres. F. EIRICH AND A. GOLDSCHMIDT. *Kolloid-Z.*, **81** [1] 7–18 (1937).—Comparison was made of measurements of the viscosity of suspensions of glass spheres by the rotating cylinder method and by the capillary viscometer. The former method gives results within 6% of those calculated from the modified

Einstein equation, whereas the latter gives low results. The difference is believed due to differences in turbulence which introduce an inertia factor in the capillary viscometer. For Part VII see "Investigation—," *Ceram. Abs.*, **16** [1] 44 (1937). F.P.P.

BULLETINS

Color analysis of Portland cement concrete. W. M. DUNAGAN. *Iowa State Coll. Agr. Mech. Arts Eng. Expt. Sta. Bull.*, No. 139, 39 pp. (1938).—A Razek-Mulder color analyzer was used, which drew a curve of per cent reflection against wave-length. Three mathematical properties of the curve were found to approximate hue (predominant wave-length), intensity (whiteness), and chroma (purity). W.D.F.

Crushing and Grinding. JOHN GROSS. *U. S. Bur. Mines Bull.*, No. 402, 148 pp. Supt. of Documents, Govt. Printing Office, Washington, D. C. Price 25¢. G. discusses the theory of crushing and grinding. Mechanical appliances are considered from a theoretical viewpoint. A bibliography is included. R.A.H.

Permissible electrically operated post drills and drilling machines. L. C. ILSLEY, E. J. GLEIM, AND H. B. BRUNOT. *U. S. Bur. Mines Repts. Investigations*, No. 3391, 17 pp. Free. Coal drills approved by the Bureau of Mines and post drills and drilling machines approved up to July 1, 1937, are described. R.A.H.

Primary crushing: Progress report No. 3. MARK SHEPPARD. *U. S. Bur. Mines Repts. Investigations*, No. 3390, 10 pp. Free. See *Ceram. Abs.*, **17** [7] 258 (1938). R.A.H.

Trend of flotation. A. J. WEINIG AND C. B. CARPENTER. *Quart. Colo. School Mines*, **32** [4] 189 pp. (1937). 4th ed., revised. Price $1.00. A detailed summary is given of the progress and trends in the flotation of commercially valuable ores and minerals. The scope of flotation is considered, and the applications of bulk flotation and selective flotation are described. The fundamental chemical and physicochemical phases of flotation are presented in detail, and the actions of chemical and physical promotors and depressants in relation to the properties of minerals are thoroughly discussed. The types of flotation reagents are described. Specific methods are described for the flotation of (1) sulfide ores of lead, zinc, iron, copper, and gold; (2) numerous nonsulfides which are insoluble and of particular ceramic importance, including chromite, feldspar, fluorspar, kyanite, magnesite, and rutile; and (3) many soluble nonsulfide ores. Numerous examples of flotation practice are given. The economic aspects of flotation are thoroughly discussed, the costs of mill construction, operation, and control and the marketing of flotation concentrates being carefully considered. Patents relating to flotation are given particular attention, patents covering equipment, processes, and reagents being listed. A valuable bibliography is included. F.G.H.

Wearing properties of metals in clay plant operation: I, Pug-mill knives, muller tires, runner plates, and screen plates. ARTHUR H. DIERKER AND J. O. EVERHART. *Ohio State Univ. Eng. Expt. Sta. Bull.*, No. 97, 21 pp. (1937).—Thirty-nine alloys were tried as pug-mill knives in actual service in a mill, and their loss of weight was determined at intervals; it varied from 0.24 to 3.84% per 100,000 brick. Physical tests were made, and photomicrographs are shown. Four materials were tested similarly as muller tires, four as dry-pan screen plates, and eight as dry-pan runner plates. The results are tabulated. See *Jour. Amer. Ceram. Soc.*, **21** [2] 69–72 (1938). W.D.F.

PATENTS

Apparatus for concentrating kaolin, etc. K. N. KLIKOVKA. Russ. 50,650, March 31, 1937; *Chem. Abs.*, **32**, 1986 (1938).—Mechanical features are described.

Conveying apparatus. H. G. HAGUE. U. S. 2,118,195, May 24, 1938 (Aug. 12, 1936).

Device for the separation of dust from flowing gases. J. MARTIN. Ger. 660,073, July 10, 1934; Cl. 12*e*. 2.01; *Chem.-Ztg.*, **62** [35] 311 (1938). D.A.B.

Drying tunnel. A. W. DE VOUT (Industrial Patents Corp.). Can. 373,537, May 3, 1938 (May 7, 1936). G.M.H.

Manufacture of an ashless and gasless solid coke suitable for the production of electrodes. VERKAUFSVEREINIGUNG FÜR TEERERZEUGNISSE, G.M.B.H. Ger. 659,542, April 1, 1934; Cl. 10*a*. 22.05; *Chem.-Ztg.*, **61** [100] 986 (1937). Addition to Ger. 644,319. D.A.B.

Means for drying large ceramic articles. DIDIER-WERKE A.-G. (Erich Hielscher, inventor). Ger. 653,055, Dec. 16, 1937; Cl. 82*a*. 1.01; *Chem. Abs.*, **32**, 2308 (1938).

Method and machine for applying slip, glaze, etc., to earthenware tile, etc. J. C. PIDDUCK. Brit. 484,473, May 18, 1938 (Oct. 5, 1936).

Method and plant for melting glass or refractory minerals in revolving tube furnaces. G. ZOTOS. Brit. 484,728, May 25, 1938 (Dec. 4, 1935).

Rotary filter. W. E. HARLOW AND F. G. GOODWIN. Can. 373,853, May 17, 1938 (June 9, 1936). G.M.H.

Spray booth. J. E. LUDWIG (DeVilbiss Co., Inc.). U. S. 2,119,282, May 31, 1938 (Aug. 24, 1936).

Surface pigmenting apparatus. C. A. WULF (Ceramic Process Co.). Can. 373,809, May 17, 1938 (Dec. 5, 1936). Can. 373,810, May 17, 1938 (Dec. 8, 1936). G.M.H.

Vibratory screen. JAMES MESS AND ROBERT STROUD (Niagara Screens & Machines, Ltd.). U. S. 2,120,032, June 7, 1938 (April 30, 1937).

Kilns, Furnaces, Fuels, and Combustion

Air in a continuous kiln. F. SCHUENHOFF. *Tonind.-Ztg.*, **61** [70] 785–87 (1937).—Air expands 4 to 5 times its volume when heated to 1200°C. This fact must be considered when building and setting a continuous kiln in order to insure good draft and rapid firing. A table of dimensions for kilns of various capacities is given. Besides maintaining combustion, the air acts as a transmitter of the heat. For intense working, a firing cycle should be not longer than 10 days. W.K.

Combustion efficiency, especially in intermittent kilns. N. STEELE GRAY. *Trans. Ceram. Soc.*, **37** [3] 100–17 (1938).—The advantages of the application of gas-pro-

ducer principles to the firemouths of kilns are (1) reduced fuel consumption, (2) elimination of smoke or minimized smoke emission, (3) improved control and temperature distribution, (4) better results with cheaper fuel, and (5) reduced labor costs. See "Smoke abatement—," *Ceram. Abs.*, **16** [1] 36 (1937). R.A.H.

Compressibility of butane-pentane mixtures below one atmosphere. F. W. JESSEN AND J. H. LIGHTFOOT. *Ind. Eng. Chem.*, **30** [3] 312–14 (1938).—This investigation was undertaken in conjunction with experiments carried out on natural-gas gathering systems and similar systems designed to supply the gases of readily liquefiable hydrocarbons as fuel for either industrial or domestic use. Illustrated. F.G.H.

Damage to muffles by controlled atmospheres. ANON. *Metal Progress*, **33** [3] 277–80 (1938).—Newer practices in gas carburizing and heat treatment in controlled atmospheres are causing some trouble with the muffles, resistors, thermocouples, and other parts made of heat-resisting alloys. Major repairs by welding are condemned, although properly welded joints in new castings will stand up under ordinary conditions in heat-treating furnaces and ceramic kilns. Oxidizing gases are relatively innocuous, but reducing atmospheres may cause trouble. F.P.P.

Design and firing of kilns: IV, Study and record of modern practice. ANON. *Brit. Clayworker*, **47** [553] 36–38 (1938).—The setting of brick and tile in downdraft kilns, the firing and cooling of the kilns, and the fuel consumption are discussed. For Parts **II–III** see *Ceram. Abs.*, **17** [7] 259 (1938). R.A.H.

Determining specific heat of gases at high temperatures by the sound-velocity method: I, Carbon monoxide. G. G. SHERRATT AND EZER GRIFFITHS. *Proc. Roy. Soc.* [London], **A147**, 292–308 (1934); *Chem. Abs.*, **29**, 989 (1935).—The apparatus and procedure are described. Data are given on CO, from 1000° to 1800°, at 2 frequencies, 7908 and 27,422 cycles per sec. The values for the apparent heat capacity were corrected for the effect of frequency to yield values for the true heat capacity that agree well with those recently calculated by various investigators from spectroscopic data. The "period of relaxation" of the vibrational energy of CO is calculated to be 1.0 to 1.2 $\times 10^{-4}$ sec. For Part **II** see *Ceram. Abs.*, **17** [7] 259 (1938).

Firing of porcelain circular furnaces with bituminous coal gas. F. DIETRICH. *Gas & Wasserfach*, **81** [18] 298–301 (1938).—A furnace fired with coal gas showed a saving under the particular conditions when compared with a gas-fired furnace. D. describes details of construction and the arrangement of the burners, the furnace, and air ducts. M.H.

Formation of nitrogen oxide (NO) during combustion of town gas, either in burners or in combustion chambers. M. P. SCHLAEFFER. *Jour. Usines Gaz.*, **62** [3] 49–63 (1938). R.W.D.

Industrial gas-heating calculations. RAYMOND F. MANN. *Amer. Gas Jour.*, p. 35 (May, 1938).—M. describes methods for calculating the gas consumption required for industrial furnaces. See *Ceram. Abs.*, **17** [7] 259 (1938). B.C.R.

Operating data of gas generators with a revolving grate. OSKAR HEIBER. *Glashütte*, **67** [51] 783–85 (1937). M.V.C.

Standards of classification of coals by rank and grade. THOMAS A. HENDRICKS. *Econ. Geol.*, **33** [2] 136–42 (1938).—H. gives the classifications of coals by rank and grade which have been adopted as American standards by the Amer. Soc. Testing Materials and the Amer. Standards Assn. The two standard classifications are summarized. J.L.G.

Thermodynamic properties of hydrocarbons. W. C. EDMISTER. *Ind. Eng. Chem.*, **30** [3] 352–58 (1938).—The effects of pressure on specific heats at constant pressure, entropy, and enthalpy are computed in reduced or generalized units for hydrocarbons. E. presents a table of generalized thermodynamic properties and equations by means of which all the thermal properties can be computed for any hydrocarbon for which critical data are available. Illustrated. F.G.H.

Tunnel kiln. B. BASSA. *Keram. Rundschau*, **45** [37] 421–22 (1937).—The multi-tunnel kiln consists of many parallel tunnels built on independent walls containing the heating flues. Each tunnel is situated between two heated walls. Heat recuperation is secured by the anticurrent principle; heat transfer is realized by radiation. Total length is usually smaller than 80 ft. The kiln is able to fire practically any kind of fine or common ceramic product. F.E.V.

Use of industrial gases and waste gases by the Lurgi processes. G. ROESNER. *Metallges. Periodic Rev.*, pp. 22–30 (1938).—R. discusses economical utilization of the noncondensable, condensable, and solid contents in waste gases, the destructive and toxic properties of the latter, and economic losses by not extracting them from the waste gases and not purifying the waste gases. The electrical gas cleaning and dust separation process of the Lurgi Co. is described. The degree of purity of the gas can reach 99% and precipitation can be applied up to 500°C; the dust is produced in a dry state so that no sludge or slurry has to be removed. The removal of SO_2 and its use in the paper pulp industry and the concentration of benzol by active carbon are also discussed. The relationship between the adsorptive capacity of active carbon and the concentration of benzol at 20°C is given as follows:

Concentration (g./m.³)	0.01	0.1	1	10	100
Adsorptive capacity (g. of benzol/100 g. of carbon)	5	8	14	25	45

Six references. M.H.

PATENTS

Kiln furniture. G. S. DIAMOND (Electro Refractories & Alloys Corp.). U. S. 2,118,641, May 24, 1938 (Nov. 13, 1936).

Manufacture of hydrocarbon gases from coal. H. DREYFUS. Brit. 478,668, Feb. 2, 1938 (July 23, 1936).

Manufacture of water gas in combination with the production of city gas by using coke ovens with externally heated vertical chambers. BRAUNKOHLEN- UND BRIKETT-INDUSTRIE, A.-G. Ger. 659,956, Oct. 21, 1933; Cl. 24*e*. 2.02; *Chem.-Ztg.*, **62** [36] 322 (1938). D.A.B.

Muffle furnace. METALLGES., A.-G. Ger. 659,979, June 11, 1936; Cl. 31*a*. 2.30; *Chem.-Ztg.*, **62** [35] 311 (1938). D.A.B.

Geology

Algerian diatomite. V. C. *Rev. Matériaux Construction Trav. Publics*, No. 340, p. 12B (1938).—The composition and characteristics of the deposits are dealt with. M.V.C.

Attapulgite. J. DE LAPPARENT. *Z. Krist.*, **97**, 237–39 (1937).—Kerr's classification of attapulgite as montmorillonite (*Ceram. Abs.*, **17** [1] 35 (1938)) is disputed. On the basis of thermal curves and X-ray patterns, attapulgite is distinguished from montmorillonite and is to be classed with the mica structures. See "Formula—," *ibid.*, **15** [11] 345 (1936). H.I.

Behavior of montmorillonite upon wetting. W. F. BRADLEY, R. E. GRIM, AND G. L. CLARK. *Z. Krist.*, **97**, 216–22 (1937).—X-ray spectrograms were taken of laminated sheets of montmorillonite crystals during exposure to atmospheres of different water-vapor contents. The evidence indicates that the swelling is not gradual but is due to five discrete hydrates having 2, 8, 14, 20, and 26 mols. of H_2O per unit cell, respectively. The first hydrate has a pyrophyllite structure in which the water is present as OH groups associated with the Al_2O_3 octahedra. The rest of the water in the higher hydrates is present as molecules packed hexagonally. H.I.

Bentonite. M. GUEDRAS. *Rev. Fonderie Moderne*, **31**, 334–38 (1937); **32**, 7–10 (1938).—Bentonite is classified as a mineral of phyllitic (leafy, laminar) structure of varying chemical composition; clays, *e.g.*, are silicoaluminous phyllites. $K(OH)_2Mg_3Si_3AlO_{10}$, $K(OH)_2Mg_3Si_4O_{10}$, and $K(OH)_2Al_2Si_4O_{10}$ are forms of mica belonging to the same class. The pyrophyllites comprise steargilite, montmorillonite, confolensite, cimolite, pagotite, agalmatolite, and fuller's earth (smectite); the average composition is 66.5 SiO_2, 28.5 Al_2O_3, and 4.9% H_2O, with varying contents of Fe_2O_3, TiO_2, CaO, MgO, and Na_2O. The properties and geological conditions of the deposits are described, and an outline of the bentonite system is established. Ten references. M.H.

Chemical constitution of the clay molecule. Review of later theories. J. W. MELLOR. *Trans. Ceram. Soc.*, **37** [3] 118–25 (1938).—The early chemical hypothesis developed by Mellor and Holdcroft has been vindicated. It alone has responded satisfactorily to a wide variety of tests. When purified clay is heated to about 550°C, it is completely disrupted to form water, free silica, and free alumina. Both solids are in the amorphous state, and, as the temperature rises, the alumina forms active γ-Al_2O_3, and, at higher temperatures, inactive α-Al_2O_3. No other theory of the action has been able to explain all the facts. Above 1000°C, the γ-alumina unites with silica to form mullite; the speed of the action is sometimes fast enough at about 1200° to produce a small hump in the heating curve. R.A.H.

Chemical equilibrium existing between soluble salts and base-exchange compounds. J. DARREL PETERSON AND D. S. JENNINGS. *Soil Sci.*, **45** [4] 277–91 (1938).—Replaceable bases were determined for soils washed with distilled water and for soils and bentonite (with and without $CaCO_3$) treated with various salt solutions. Calcareous soils, when in contact with $NaHCO_3$, contain more replaceable sodium than when the soluble salts have been removed. All replaceable sodium in calcareous soils may be replaced by continued leaching with distilled water. When a soil or bentonite is brought into contact with a salt solution, all types of cations present in the solution enter into the exchange complex. The bases present in the solid phase, after the chemical treatment is complete, are independent of the nature of the replaceable bases present before the treatment. Replaceable calcium was present in soils and bentonite treated with salts of sodium and potassium, especially when $CaCO_3$ was present. The base-exchange capacity for bentonite was less when treated with potassium than when treated with sodium or calcium. The sum of the separate replaceable bases is usually higher than the total base capacity as indicated by the absorbed ammonia. 31 references. G.R.S.

Constitution and properties of some clayey materials (bentonite and kaolin). V. PREVER AND C. GORIA *Chimica & Industria*, **19** [6] 305–12 (1937).—A thorough investigation of two bentonites and a Sardinian kaolin showed the surface conditions to be of lesser importance than the faculty of absorption. The properties and mineral constituents of the materials can be determined better by thermal analysis than by physical and chemical analysis. M.H.

Czechoslovak glassmelting sands. ZD. SCHAEFER. *Sklářské Rozhledy*, **14** [5–6] 85–95 (1937).—The necessary physical and chemical properties of sands for glassmelting processes in various branches of the industry are given, and the available local sands are classified as follows: (1) sands having a maximum content of 0.02% Fe_2O_3, suitable for the production of crystal ware, (2) sands containing 0.02 to 0.20% Fe_2O_3, suitable for commercial glassware, and (3) sands with an Fe_2O_3 content higher than 0.20%. E.P.

Density and structure of zircon: II. M. v. STACKELBERG AND K. CHUDOBA. *Z. Krist.*, **97**, 252–61 (1937).—Two zircons having densities of 3.972 and 3.945 were found to be composed of a mixture of amorphous SiO_2 and microcrystalline ZrO_2 and a mixture of amorphous SiO_2 and amorphous ZrO_2, respectively, indicating that low density in zircon is not always to be ascribed to an enantiomorphic form of Zr_2SiO_4. For Part I see *Ceram. Abs.*, **16** [8] 256 (1937). H.I.

French studies on clay in 1937. M. D. *Rev. Matériaux Construction Trav. Publics*, No. 341, pp. 26–28B (1938). M.V.C.

List of principal works relating to the geology, mining, and engineering of Cornwall available in or through the Falmouth Library. W. TREGONING HOOPER. *Sands, Clays & Minerals*, **3** [3] 233–34 (1938).—Literature from 1542 to 1936 is compiled. M.H.

Magnesium, the metal. L. SANDERSON. *Sands, Clays & Minerals*, **3** [3] 187–89 (1938).—S. discusses the discovery of Mg and developments up to the present time. The metal is found principally in the following ores: periclase (MgO), brucite ($Mg(OH)_2$), hydrotalcite or volkerite ($3Mg(OH)_2$), pyroaurite ($3Mg(OH)_2 \cdot Fe(OH)_3 \cdot 3H_2O$), spinel ($Mg(AlO_2)_2$), magnesioferrite ($Mg(FeO_2)_2$), pleonaste or iron spinel ($(MgFe)[(AlFe)O_2]$), picotite or chromospinel ($(Mg,Fe)[(Al, Fe,Cr)O_2]_2$), manganospinel (MgMn-

$[(Fe,Mn)O_3]_2$); in the silicates talc, chlorite, serpentine; and in the carbonates magnesite ($MgCO_3$), dolomite ($(MgCa)CO_3$), ankerite ($(CaMgFeMn)CO_3$), breunnerite ($(MgFe)CO_3$), and nesquehonite ($MgCO_3 \cdot 3H_2O$). The production processes chiefly used and forms and fields of application are briefly described. M.H.

Mica-like minerals as clay substances. EDMUND MAGDEFRAU AND ULRICH HOFMANN. *Z. Krist.*, **98**, 31–59 (1937).—On the basis of a study of two mica-like minerals occurring abundantly in soils, the authors conclude that (1) chemically, optically, and structurally, the minerals are closely related to the micas; (2) the smaller number of interference lines, as compared with muscovite and biotite, indicates that these minerals may be orthorhombic; (3) in calculated number of ions per unit cell, the two minerals correspond well with structures of micas; (4) the alkali content is somewhat lower and the water content somewhat higher than that of the micas; (5) the minerals possess considerable base exchange capacity and settle slowly in water suspensions; (6) next to kaolinite and montmorillonite, such mica-like minerals are among the most important clay substances. H.I.

Newer developments in beryllium. C. B. SAWYER AND B. R. KJELLGREN. *Ind. Eng. Chem.*, **30** [5] 501–505 (1938).—The supply of beryl ore continues to develop and is more than adequate. A better method of chemical analysis is needed to aid in the further development of ore deposits. Pure beryllium oxide with a melting point of 2570°C is admirably adapted for refractories. This melting point is about 500° higher than that of alumina. Articles of beryllia may be extruded or pressed with or without binder into large or small forms. When properly prepared, they show excellent electrical insulating qualities at high temperatures and good resistance to thermal shock; the latter quality permits repeated heats to be made from the same crucible. A German firm advertises ceramic products of beryllia which are entirely gastight at 2200°C. They resist molten alkalis but are susceptible to acid attack. They are only slightly attacked, even at high temperatures, by carbon, carbon monoxide, or hydrogen. Oxides such as alumina, magnesia, etc., however, readily form slags with beryllia. Zirconia does not react, even at 1900°C. Especially noteworthy is the small loss in the presence of high-frequency waves. Standard-size pressed brick are available. They are fired at 1500°C and may be fabricated sufficiently soft to permit machining. Although these brick may be made to vary in bulk density from 1.42 to 2.09, the raw beryllium oxide has a density of about 3.02, which is practically identical with that of fused beryllia. Beryllia confers some of its good properties on ceramic mixtures containing other oxides. There is some ceramic demand for raw beryl, whose beryllia content is obtained already combined with silica and alumina. Beryllia additions to glass show some possibilities. Illustrated. F.G.H.

Occurrence and preparation of china clay. E. H. DAVISON. *Sands, Clays & Minerals*, **3** [3] 195–98 (1938).—Geological conditions of deposits of china clay in Cornwall and other southern districts of England are explained; the clay is of magmatic origin. M.H.

Ore microscopy and its practical applications. WILLIAM R. JONES. *Bull. Inst. Mining & Met.*, No. 403, 35 pp. (1938).—J. discusses the nature of polished mineral surfaces, optical phenomena produced by polished mineral surfaces, preparation of polished surfaces, the ore microscope, objectives suitable for ore microscopy, light source, instruments for determining reflectivity of opaque minerals, microscopic examination of polished surfaces, microchemical tests, etch reactions, and application of ore microscopy to ore-treatment problems. A.H.E.

Pegmatite, an essentially ceramic rock. V. CHARRIN. *Céram., Verrerie, Email.*, **5** [12] 415–16 (1937).—The origin and characteristics of pegmatite and the chief deposits in France are briefly discussed. M.V.C.

Preparation, composition, and chemical behavior of the complex silicates of magnesium, calcium, strontium, and barium. L. T. KARDOS AND J. S. JOFFE. *Soil Sci.*, **45** [4] 293–307 (1938).—The affinity of the Mg^{++} ion is greater than that of the Ca^{++} ion for the SiO_3^{--} ion. The affinity of the Mg^{++} ion for the highly multivalent silica sol can hardly be ascribed to the adsorbed OH^- ion and thereby to the formation of insoluble $Mg(OH)_2$ in the interface, since it has been indicated from purely theoretical considerations that the colloidal silicic acid solutions belong to the class of strong acids and are stronger than truly soluble acids of similar basicity, *i.e.*, from the standpoint of the number of electron charges with which each particle is combined. The mutual electron affinities of Mg and O plus the ionization potentials, both of which contribute to the lattice energy and therefore to the rigidity of the bond between the associated atomic ions and the inner layer, indicate the Mg-O linkage to be stronger than the linkage of the alkaline-earth cations with oxygen. The table of hardness of the oxides indicates the relationship. This Mg-O affinity is maintained and accentuated by the presence of the silicon atom; this is indicated by heats of formation of silicates. That Mg should not behave like Ca, Sr, and Ba is more to be expected than that it should. Among the organo-metallic compounds, only one Ca of the type R-Ca-X(C_2H_5-Ca-I), none of Sr or Ba, and hundreds of Mg compounds of various types are listed. The stability of the Mg in its compounds seems irrevocably related to the oxygen ion, and the degree to which the nature and magnitude of the "force" field of this ion is modified by the atom (such as H, Si, C, P, S) to which the oxygen is attached in the hydroxide, silicate, carbonate, phosphate, or sulfate governs the solubility of the respective salts. 35 references. G.R.S.

Pyrophyllite. R. LEDUC. *Rev. Matériaux Construction Trav. Publics*, No. 340, p. 11B (1938).—L. discusses briefly the nature of pyrophyllite and its use in refractory linings. M.V.C.

Refining diatomite. PAUL D. V. MANNING. *Chem. & Met. Eng.*, **45** [1] 28 (1938).—Methods used in mining and refining diatomite from the Palos Verdes deposit in Calif. are described. B.C.R.

Salt domes and their ceramic deposits. R. A. STEINMAYER. *Bull. Amer. Ceram. Soc.*, **17** [6] 260–62 (1938).

Serpentine rocks in ceramics. VICTOR CHARRIN. *Céram., Verrerie, Email.*, **6** [2] 52–53 (1938).—The chief varieties of serpentine rock, forsterite, olivine, and talc or steatite, are used mostly in the refractory industry. M.V.C.

Softening water by filtration. V. CHARRIN. *Argile,*

No. 179 (March), pp. 1–5 (1938).—The use of natural and synthetic zeolites, which may be considered as hydrated feldspars, for filtering water is discussed. The composition of the best-known natural zeolites is given. Artificial zeolites are obtained by mixing solutions of sodium silicate and sodium aluminate under definite thermal conditions and concentrations which are secret. Some of the products are a result of calcining siliceous clay in the presence of caustic soda. Silicalite, a synthetic product, is manufactured from bauxite. M.V.C.

Soil humus: II, Potentiometric study of the formation of humic acid and humates. A. N. PURI AND ANAND SARUP. *Soil Sci.*, **45** [2] 165–74 (1938).—The formation of humic acid and of humates was studied by following the changes in the hydrogen-ion concentration of the reaction media. The complete precipitation of humic acid and of insoluble humates from sodium humate takes place when all of the sodium in the sodium humate has been replaced. The bearing of this phenomenon on the lack of stoichiometric proportion in humates is discussed. For Part I see *Ceram. Abs.*, **17** [2] 83 (1938). G.R.S.

Structural formulas and classification of clays. J. DE LAPPARENT. *Z. Krist.*, **98**, 233–58 (1937).—Clay minerals are classified into three types on the basis of structural similarities and thickness of the elementary lamella: (1) kaolinite-anauxite type with a thickness of about 7Å, including kaolinite with varieties dickite and nacrite, anauxite, beidellite, and halloysite, and the nonaluminous equivalent, serpentine; (2) attapulgite type with thickness of about 10Å, including pyrophyllite, attapulgite, and the nonaluminous equivalents, talc and sepiolite; and (3) the montmorillonite type with thickness of about 14 Å, including montmorillonite and nontronite. H.I.

Texas ceramic industry. E. P. SCHOCH AND DAVID MCKNIGHT, JR. *Bull. Amer. Ceram. Soc.*, **17** [6] 262–66 (1938).

Uniform classification of ceramic plastic clays. OTAKAR KALLAUNER. *Bull. Amer. Ceram. Soc.*, **17** [6] 251–53 (1938); see *Ceram. Abs.*, **17** [6] 231 (1938).

X-ray investigations on clays: III, Differentiation of micas by X-ray powder photographs. G. NAGELSCHMIDT. *Z. Krist.*, **97**, 514–21 (1937).—X-ray powder photographs of eight micas, including two lithium micas and sericite, are recorded. They all belong to either the muscovite or the phlogopite-biotite type. Of the two lithium micas, lepidolite resembles the muscovite type and zinnwaldite, the biotite type. The unit cell of muscovite can be written as $K_4Al_8(Si_{12}Al_4O_{40})(OH)_8$, the first 8 Al atoms being 6-coördinated and replaceable by Fe'''. Identification of micas by X-rays in fine-grained mixtures such as soils presents considerable difficulty unless the mica content is large. For Parts I–II see *Ceram. Abs.*, **14** [4] 100 (1935). H.I.

BOOKS

Descriptive Petrography of the Igneous Rocks: Vol. IV. ALBERT JOHANNSEN. Univ. of Chicago Press, Chicago, 1938. 523 pp. Price $4.50. Reviewed in *Eng. Mining Jour.*, **139** [4] 59 (1938).—In this concluding volume 393 pages are devoted to feldspathoids and 74 pages to peridotites and perknites. The indexes of authors, localities, and rock names cover the contents of Vols. II–IV. Twenty-eight new mineral names appear in this volume. For Vol. II see *Ceram. Abs.*, **12** [10–11] 397 (1933). J.L.G.

Economic Geology. H. RIES. John Wiley & Sons, New York, 1937. 7th ed. 720 pp. Price $5. Reviewed in *Eng. Mining Jour.*, **139** [4] 59 (1938).—Nonmetallic mineral products, their origin, properties, distribution, and uses, and metallic ores are considered. J.L.G.

Mining Year Book, 1938. Compiled and published by WALTER E. SKINNER, London. 1060 pp. Price 20s net; 21s 6d post free abroad. Reviewed in *Eng. Mining Jour.*, **139** [4] 59 (1938).—Particulars of 1325 of the world's principal mining companies, together with lists of directors and mining and consulting engineers, are given. 25 sketch maps. J.L.G.

PATENTS

Geophysical method of determining geological structures. E. V. MCCOLLUM AND L. F. ATHY (Continental Oil Co.). U. S. 2,118,442, May 24, 1938 (June 30, 1934).

Method of making geological explorations. E. V. MCCOLLUM (Continental Oil Co.). U. S. 2,118,441, May 24, 1938 (Feb. 5, 1934). A method of measuring intervals between buried geological layers from the earth's surface includes the steps of generating waves at or near the earth's surface, receiving reflections of waves from buried geological layers at a point at or near the earth's surface positioned close enough to the wave source to subtend small angles at the points on the geological layers from which reflections take place.

Titanium ore processing. R. H. MONK AND A. S. ROSS (American Zinc, Lead & Smelting Co.). Can. 373,650, May 10, 1938 (July 22, 1936; in U. S., July 24, 1935). G.M.H.

Chemistry and Physics

Adsorption of precipitates: I, Adsorption by iron, aluminum, and chromium hydroxides. N. A. YAJNIK, P. L. KAPUR, AND R. L. MALHOTRA. *Kolloid-Z.*, **80** [2] 152–55 (1937).—The adsorption of numerous anions by the precipitated hydroxides of Al, Fe, and Cr was measured and their relative adsorptive abilities were graded. The relative adsorptions of the ions tested depended not only on their valencies but on specific chemical factors, such as the formation of insoluble or complex salts. F.P.P.

Advances in ceramic opacifiers. BÜTTNER. *Keram. Rundschau.* **45** [11] 120–21 (1937).—Opacification with residues of the thorium industry gives yellowish glazes due to lanthanum and didymium. A new preparation called opaline contains cerium oxide without didymium. Glazes with limited contents of PbO and 3 to 4% opaline are perfectly white. There is no reduction to metallic lead. Opaline is advantageous from the economic viewpoint. F.E.V.

Agglomeration and viscosity in dilute suspensions. G. BROUGHTON AND C. S. WINDEBANK. *Ind. Eng. Chem.*, **30** [4] 407–409 (1938).—Experiments with suspensions of spherical glass and kaolin particles in an inert organic

mixture of equal density, in which marked agglomeration of particles was observable, indicate that the Einstein relation,

$$\eta = \eta (1 + 2.5\ V),$$

holds only for spheres of relatively large size (50 to 200μ) at low concentrations. Conclusions as to the volumetric relations in colloidal systems based on the use of the Einstein formula, even for spherical particles, can be grossly misleading unless absence of agglomeration is assured. Illustrated. F.G.H.

Analysis of phosphate rock. JAMES I. HOFFMAN AND G. E. F. LUNDELL. *Jour. Research Nat. Bur. Standards*, **20** [5] 607–26 (1938); R.P. 1095. Price 5¢.—The methods used in the analysis of the two Standard Samples of Phosphate Rock, 56a and 120, are described, and a summary of the results obtained by nine coöperating analysts is given. R.A.H.

Bicalcium silicate. A. I. KORSHUNOVA. *Vsesoyuz. Nauchno-Issled. Inst. Tsementov*, No. 17, pp. 34–39 (1937).—A mixture of pure CaO, purified quartz powder, and boric acid was fired to 1420° to obtain beta C_2S. After firing, the silicate represented a white hard lustrous crystallized mass. The chemical analysis was 34.12 SiO_2, 63.94 CaO, and 0.5% B_2O_3, used to promote stabilization. The petrographic analysis showed the presence of 90 to 95% beta C_2S. Experiments made to determine the characteristics of the silicate are briefly discussed. M.V.C.

Coloration of glasses, enamels, and natural gems. ANON. *Nature* [Paris], No. 3025, pp. 312–13 (1938).—A great variety of colored glasses, enamels, and natural colored crystals may be considered as colloid systems. R.W.D.

Colorimetric determination of silica in lime solutions. E. I. NAGEROV AND A. D. PETROV. *Vsesoyuz. Nauchno-Issled. Inst. Tsementov*, No. 17, pp. 56–60 (1937).—The colorimetric determination of silica in lime solutions is based on the formation of a colored complex with molybdate of ammonium. Tables of results are given. M.V.C.

Dithizone method for measurement of small amounts of zinc. P. L. HUBBARD. *Ind. Eng. Chem., Anal. Ed.*, **9** [3] 127–31 (1937).—H. describes a simple, convenient, quickly performed dithizone test for estimating amounts of zinc of 0.001 to 0.100 mg. and discusses means for overcoming several difficulties which may appear. Many other metals besides zinc produce colored complexes with dithizone. By means of suitable solvents, the use of which is described, zinc is separated from other metals which are most likely to interfere in the estimation of the zinc. F.G.H.

Electrodialysis of soils: III, Speed of electrodialysis of various cations. A. N. PURI AND R. C. HOON. *Soil Sci.*, **45** [4] 309–13 (1938).—Experimental evidence supports the contention that differences in the rate of electrodialysis of different cations in soil are due to the differences in their ionic activities. Such differences would come into play only in the case of salts of insoluble acids such as aluminosilicates. For Part I see *Ceram. Abs.*, **16** [7] 218 (1937). G.R.S.

Longitudinal waves of very high frequencies in viscous liquids. R. LUCAS. *Compt. Rend.*, **206** [9] 658–59 (1938).—L. presents a mathematical study. M.H.

Low-density zircons. JOACHIM LIETZ. *Z. Krist.*, **98**, 201–10 (1937). H.I.

Microdetermination of calcium. G. H. ELLIS. *Ind. Eng. Chem., Anal. Ed.*, **10** [2] 112 (1938).—A dilute perchloric acid solution of calcium oxalate is titrated with hexanitrato ammonium cerate, using orthophenanthroline ferrous complex or setopaline C as an indicator. F.G.H.

Microgasometric analysis with the dilatometer. BEVERLY L. CLARKE AND H. W. HERMANCE. *Ind. Eng. Chem., Anal. Ed.*, **9** [12] 597–98 (1937).—The determination of the carbonate radical is described and illustrated. F.G.H.

Qualitative separations on a microscale. Analysis of the alkali group. A. A. BENEDETTI-PICHLER AND JAMES T. BRYANT. *Ind. Eng. Chem., Anal. Ed.*, **10** [2] 107–10 (1938).—A procedure is proposed for the qualitative analysis of the alkali group from 1-mg. solid samples. Sulfate ion is removed as barium sulfate. Chloroplatinic acid is used for the separation of the potassium and sodium subgroups. The analysis of the sodium subgroup follows the scheme of Noyes and Bray. The work is carried out in microcentrifuge cones of clear fused quartz and of Pyrex glass. F.G.H.

Quantitative spectrochemical analysis. Chemical and metallurgical applications. J. S. OWENS. *Ind. Eng. Chem., Anal. Ed.*, **10** [2] 64–67 (1938).—The quantitative spectrochemical method has proved its worth as an analytical tool in the metallurgical and chemical industries. O. outlines the development of special equipment and technique, important for the attainment of greater sensitivity, accuracy, and rapidity of analyses in routine industrial use. Illustrated. F.G.H.

Rare-earth salts. Precipitation and p_H studies with the glass electrode. J. A. C. BOWLES AND H. M. PARTRIDGE. *Ind. Eng. Chem., Anal. Ed.*, **9** [3] 124–27 (1937).—Titrimetric and p_H studies with the glass electrode and vacuum-tube null-indicator of some rare-earth salts and thorium sulfate at 25°C were made. A method for separating cerium from lanthanum by simply controlling the p_H of the solution is suggested. Illustrated. F.G.H.

Reagent for the detection of cerium. J. F. MILLER. *Ind. Eng. Chem., Anal. Ed.*, **9** [4] 181–82 (1937).—The red-brown color produced by arsanilic acid with ceric solutions is very sensitive and can be used in the qualitative detection of cerium in the presence of the elements with which it is commonly found. Fluoride, zirconium, cobalt, and chromium interfere. The reaction is unsatisfactory for exact quantitative work. Arsanilic acid can be used as an outside indicator for ceric sulfate titrations, but not as an inside indicator. F.G.H.

Reciprocal action of CaO and Cr_2O_3 on heating: I. F. I. VASENIN. *Vsesoyuz. Nauchno-Issled. Inst. Tsementov*, No. 17, pp. 40–51 (1937).—When heating CaO and Cr_2O_3 in air at a rate of 10°/min., only two mixtures, in which the ratio of CaO to Cr_2O_3 is 1:1 or 1:3, will yield melts with a homogeneous crystallized structure. Calcium chromite, $CaOCr_2O_3$, is obtained from the first mixture at over 1020° with distinctive green prismatic crystals, while from the second, $3CaOCr_2O_3$ is obtained at over 1020°; it has anisotropic crystals of irregular shape. Chromates are formed first at temperatures between 600°

and 800°; they later change into chromites at over 1020°. M.V.C.

Relative desulfurizing power of blast-furnace slags: II. W. F. HOLBROOK. *Metals Tech.*, **5** [1] T.P. 875 (1938).—Any possible slag within the range 30 to 50% SiO_2, 5 to 25% Al_2O_3, and 35 to 65% (CaO + MgO) will be comparatively desulfurizing at 1500°C. Increased basicity improves desulfurization, but for a given MgO content, there is an optimum basicity beyond which the slags become very poor desulfurizers. Increase of temperature from 1475° to 1525°C doubled the desulfurization ratio of most ordinary blast-furnace slag compositions. Diagrams indicate the magnitude of the change in desulfurizing power that may be expected from any given change in composition or temperature of a slag. F.P.P.

Separation of magnesium as oxalate by precipitation in concentrated acetic acid solution. PHILIP J. ELVING AND EARLE R. CALEY. *Ind. Eng. Chem., Anal. Ed.*, **9** [12] 558–62 (1937).—Magnesium can be quantitatively precipitated as the oxalate in 85% acetic acid solution. The precipitate may be ignited to oxide for the gravimetric determination of magnesium; for the volumetric determination, the oxalic acid liberated by dissolving the magnesium oxalate in dilute sulfuric acid may be titrated with a standard permanganate solution. The alkalis can be conveniently determined in the filtrate after separation of the magnesium by this method. F.G.H.

Spectrophotometric method for determining iron in ores. J. P. MEHLIG. *Ind. Eng. Chem., Anal. Ed.*, **9** [4] 162–63 (1937).—The spectrophotometric method employing the molecular extinction coefficient has been satisfactorily applied to the determination of iron by measuring the transmittancy of light at given wave-lengths through the system consisting of the amethyst-colored complex formed by the addition of salicylic acid to ferric ions in acetic acid solution. The spectrophotometric method gives results for iron in ores which check well with those given by the dichromate method. F.G.H.

Structure of high cristobalite. W. NIEUWENKAMP. *Z. Krist.*, **96**, 454–58 (1937).—The determination of the structure of high cristobalite by X-ray rotation photographs indicates that the experimental structure factors agree with a structure founded on O_h^7 = Fd3m containing Si in 000, $^1/_4$ $^1/_4$ $^1/_4$, etc., positions and O either (*a*) rotating on a circular orbit of radius approximately 0.4Å about the line Si-Si as axis, or (*b*) distributed statistically over point positions containing points on this orbit. H.I.

Theory of the glass electrode: I. B. P. NICOLSKY. *Acta Physicochim. U. R. S. S.*, **7**, 597–610 (1937) (in English); *Jour. Soc. Glass Tech.*, **22** [89] A3 (1938).—N. studied mechanism of the glass-electrode function, according to which a thin (but polymolecular) layer of glass at the surface enters into equilibrium with a solution. During the establishment of this equilibrium an exchange of Na and H ions takes place in the glass surface layer. The equilibrium of this exchange is determined by the equilibrium constant (the constant of ion exchange) which characterizes the difference in the strength of Na- and H-ion linkage in the glass as compared with that in the solution. On the basis of this mechanism, N. developed a thermodynamic theory of the glass electrode, leading to the formula $E = E^\circ + (RT/F)$ in $(a_{H^+} + K a_{Na^+})$, in which E is the e.m.f. of the glass electrode cell, a_{H^+} and a_{Na^+} are the activities of H and Na ions in solution, and K is the constant of H- and Na-ion exchange.

Thermal decomposition of mixed "ammonium-calcium" permutites, bentonites, and clays. O. BOTTINI. *Kolloid-Z.*, **80** [1] 56–59 (1937).—The percentage dissociation of NH_3 loss of the mixed materials was determined at different temperatures between 50° and 550°C. For a given material, the results varied with the method of preparation, indicating that the intermicellar-bound ammonium ion is more resistant to thermal decomposition than is the extramicellar ammonium ion. See *Ceram. Abs.*, **16** [9] 289 (1937). F.P.P.

BOOKS

Diffusion and Chemical Reaction in the Solid Phase. WILLIAM JOST. Theodor Steinkopff, Leipzig, 1937. Reviewed in *Brit. Clayworker*, **47** [553] 60 (1938).—In spite of the fact that all ceramic processes and manufacture are based on chemical reactions in the solid phase and although these chemical reactions have been used for thousands of years, not much is known about the actual theoretical rules which govern the reactability of solid substances. J. endeavors to develop these theories, and the volume should be a help in all ceramic research. R.A.H.

PATENTS

Apparatus for separating magnesium, beryllium, etc., which distill from their ores and compounds. H. A. BLACKWELL AND W. L. TURNER. Brit. 484,429, May 18, 1938 (Feb. 16, 1937).

Artificial zeolites and method of making. BURGESS ZEOLITE CO., LTD. Brit. 484,549, May 18, 1938 (Sept. 30, 1936).

Making alkali subsilicate products. PENNSYLVANIA SALT MFG. CO. Brit. 484,547, May 18, 1938 (Sept. 3, 1936).

Manufacture of lime-free magnesia. O. KIPPE AND KLÖCKNER-WERKE, A.-G. Ger. 606,538, May 26, 1934; Cl. 12*m*. 3; *Chem.-Ztg.*, **61** [100] 985 (1937). D.A.B.

Process for obtaining magnesium oxide from dolomitic rock. W. H. MACINTIRE (American Zinc, Lead & Smelting Co.). U. S. 2,118,353, May 24, 1938 (Feb. 15, 1937). The process consists in forming a cold-water suspension of a comminuted dolomitic calcine comprising $CaCO_3$ and MgO, permitting hydration of the suspended MgO to ensue, bringing the hydrated MgO content of the calcine into solution by injecting hydrogen sulfide gas into the suspension, clarifying the solution, and boiling it.

Titanium dioxide preparation. R. H. MONK AND A. S. ROSS (American Zinc, Lead & Smelting Co.). Can. 363,-651, May 10, 1938 (Oct. 15, 1936); see *Ceram. Abs.*, **17** [5] 203 (1938). G.M.H.

General

Armco research laboratories. ANSON HAYES. *Ind. Eng. Chem., Anal. Ed.*, **10** [2] 97–100 (1938).—Illustrated. F.G.H.

Ceramic industry at the New York World's Fair, 1939. ANON. *Bull. Amer. Ceram. Soc.*, **17** [6] 283 (1938).

Clay mined at 2$^1/_2$ cents a yard. ANON. *Excavating*

Engr., **32**, 258–62 (1938).—At the Bell Clay Co. mine (Gleason, Tenn.), 50 ft. of overburden, mainly sticky red sand, is removed in three or four benches by a bull grader mounted on a Diesel powered caterpillar tractor, which pulls a 4.5 yd. scraper. The scraper load is dropped on the spoil pile, and the grader is used to blade it off the end. W.D.F.

Combating silicosis in New York State. H. C. Chellson. *Eng. Mining Jour.*, **139** [4] 56–58 (1938).—A list of dust control equipment approved by the N. Y. Industrial Board is given. Some is described in detail. 4 photographs. J.L.G.

Control of silicosis in mining. Donald E. Cummings. *Amer. Inst. Mining Met. Engrs. Tech. Pub.*, No. 930; *Mining Tech.*, **2** [3] 21 pp. (1938).—Two factors, susceptibility of the exposed individual to silicosis and degree of harmful exposure, are involved. Engineering control is discussed thoroughly. W.D.F.

Crazing of glazes. Anon. *Keram. Rundschau*, **45** [46] 527–28 (1937).—Crazing has two aspects: separate hairlines and nets of cracks. These aspects do not characterize a given type of glaze. The thickness of the glaze, its thermal treatment, and the formation of an intermediate layer are determining factors. F.E.V.

Health hazards in the plating industry. Cleveland Branch, A.E.S. *Monthly Rev. Amer. Electroplaters' Soc.*, **24**, 585–99 (Aug., 1937); *Metals & Alloys*, **9** [4] MA238 (1938).—The health hazards arising in metal-finishing operations are discussed with special attention to silicosis. The effects of fumes from cleaning solutions and cyanide and Cr plating baths, Pb poisoning, and Ni itch are mentioned, together with precautions and remedies.

Heat-insulating materials. Ezer Griffiths. *Jour. Sci. Instruments*, **15** [4] 117–21 (1938).—Materials used are discussed in general. Several types of tests used by the National Physical Laboratory are briefly outlined. Refrigerator insulating materials, with their conductivities, are listed. 17 references. See "Apparatus—," *Ceram. Abs.*, **16** [2] 63 (1937). J.L.G.

Industrial operations presented by means of tables, graphs, and charts. K. Glovna. *Glashütte*, **68** [1] 3–8 (1938). M.V.C.

Laboratory tests on the movement of dusts. A. M. Bryan and J. Smellie. *Jour. Roy. Tech. Coll.* [Glasgow], **4** (Part 2), 406–14 (1938).—Original research on the ease of removal of various dusts and dust sizes from glass plates at differing air-blast velocities is reported. Graphs and a discussion show the effect of surface resistance, previous wetting of the dust-laden surface, etc., on movement of the dusts. W.H.B.

Joseph William Mellor, 1869–1938. Anon. *Bull. Amer. Ceram. Soc.*, **17** [6] 278–83 (1938).

Metal ceramics molded from powder. S. L. Hoyt. *Metal Progress*, **33** [2] 157–62 (1938).—The manufacture, properties, and applications of 2-phase products of powder metallurgy, such as Cu-W electrodes for spot welding, porous bronze-graphite bearings, and cemented carbide tool materials, are discussed. F.P.P.

Powder metallurgy. Tungsten and other refractory metals. S. L. Hoyt. *Metal Progress*, **32** [6] 749–54 (1937).—H. reviews the origin of powder metallurgy and discusses its modern application to the production of W, Mo, Ta, and Cb filaments and sheets. F.P.P.

Pressing problems of material testing in the building field. Hans Hecht. Read before German Soc. for Testing Materials, Düsseldorf, Oct., 1937; abstracted in *Chem.-Ztg.*, **61** [98] 963 (1937). D.A.B.

Reaction of the living body to mineral dusts with and without complicating infection. Leroy U. Gardner. *Amer. Inst. Mining Met. Engrs. Tech. Pub.*, No. 929; *Mining Tech.*, **2** [3] 15 pp. (1938).—Minerals having a particle size of 3μ and smaller were injected in the livers of rabbits and guinea pigs. There was no important difference between reactions of the two animals. The least observable reaction is indicated by ±; 5 + represents the standard reaction for quartz. An 8+ reaction was given by colloidal silica (dispersed) and sodium silicate, while colloidal silica gel gave only ±; 7+ was given by tridymite; 6+ by cristobalite; 5+ by quartz, vitreous silica, chalcedony, tripoli, flint, and diatomite; 4+ by opal; and 3+ by biotite. All others were lower. Eleven forms of free silica, 23 silicates (including sericite, +), 14 nonsilicates, and 10 mixtures of quartz with other dusts were tested. There was a variable amount of protection in every case. Infections may give a bad reaction with only mildly irritant dust, or the scar tissue in healed infections may interfere mechanically with dust removal from the organ. Free silica in the body specifically stimulates tubercle bacilli. W.D.F.

Scrapers replace graders for clay stripping. Anon. *Excavating Engr.*, **32**, 209–11 (1938).—At the Ochs Brick and Tile Co. (Springfield, Minn.), the overburden, ranging from 25 to 40 ft., is sliced down to a slope by two 5-yd. scrapers, hauled by Diesel tractors. The final thin layer is not stripped off until the clay is needed. W.D.F.

Steam contamination: I, Causes, correction, and measurement. S. T. Powell. *Combustion*, **9** [3] 36–40 (1937).—P. takes up the influence of boiler design and operating conditions on priming and foaming, the influence of dissolved and suspended solids, and the phenomenon of selective carry-over of solids contained in concentrated boiler-water salines. Results of numerous investigations are cited, and an extensive bibliography is included. H.E.S.

Steam power developments. C. W. E. Clark. *Combustion*, **9** [5] 41–44 (1937).—Present steam station practice, particularly among the utilities and large industrials, which would be applicable to steel plant service is reviewed. H.E.S.

Strength of unfired ceramic bodies. H. von Wartenberg. *Angew. Chem.*, **50**, 734–37 (1937).—W. discusses molten Al_2O_3, MgO, ZrO_2, BeO, etc., where no hydroxides act as adhesive materials. He made tests to determine whether the strength of an article molded when wet and then dried increases strongly with the degree of dispersion and whether an influence of the surface tension of different liquids is noticeable. He found that, when wetted with liquids, the grains of a powder of the materials tested are forced together by the surface tension. Afterwards the molecular forces effect the further cohesion at the points of contact. The surface tension of different liquids is noticeable only up to grains of about 10μ. When the liquids do not completely wet the material, the surface

tension causes flocculation and reduces the strength. Extensive formulas and tables are given. E.W.S.

Study of the crystalline siliceous minerals present in silicotic lungs by the X-ray diffraction method. C. M. Jephcott, W. M. Gray, and Dudley A. Irwin. *Can. Med. Assn. Jour.*, **38**, 209–15 (1938); *Chem. Abs.*, **32**, 3507 (1938).—Examination of the ash from the lungs of 35 men exposed to dusts containing free and (or) combined silica, by the X-ray diffraction method, shows that quartz is present as a chief constituent of these ashes. In the majority of cases, representatives of the mica and feldspar group are present only in unimportant quantities. While some quantitative information is gained, no definite correlation can be demonstrated between the crystalline siliceous material of the lung ash and the occupational history of the individual.

BOOKS

Laboratories that make assays, analyses, and tests on ores, minerals, and other substances. C. W. Davis and M. W. von Bernewitz. *U. S. Bur. Mines Information Circ.*, No. 6999, 25 pp. Free. Laboratories located in the U. S., Canada, and Mexico are included. R.A.H.

Notebook for Glass, Ceramics, Enamel, and Cements, 1938 (Agenda pour Verrerie, Céramique, Émaillerie, Cimenterie, 1938). Jacques Wolf. Éditions Ceremver, Bruxelles. 278 pp. The first part consists of a calendar and general information. The second part contains abstracts of articles dealing with ceramic technology. A list of Belgian and French ceramic manufacturers and industries related to ceramics and various physicochemical data comprise the rest of the book. M.V.C.

Review of literature on conditioning air for advancement of health and safety in mines. D. Harrington and Sara J. Davenport. *U. S. Bur. Mines Information Circ.*, No. 7001, 38 pp. Free. R.A.H.

Safety catches and arresting devices for cages, skips, and cars in mine shafts and slopes. Mine Safety Board Decision 28. Mine Safety Board. *U. S. Bur. Mines Information Circ.*, No. 7002, 2 pp. Free. No device known can be relied upon absolutely to arrest cages, skips, and cars in all conceivable contingencies. R.A.H.

PATENTS

Art of treating oil-decolorizing clays. H. L. Kauffman. U. S. 2,118,310, May 24, 1938 (Oct. 23, 1934).

Impregnation and enameling of clayware. Miksa Steinlechner. Hung. 116,768, Aug. 16, 1937; *Chem. Abs.*, **32**, 3116 (1938).—The ware is impregnated with a solution of 5 to 30% $Al_2(SO_4)_3$, alkali silicate, soap, or their mixture. Then a coating of natural or artificial resins in alcohol or benzene solution is applied, and the ware is heated at 50° to 300°.

Mud mixer and equalizer. W. O. Vermillion (J. E. Vermillion, W. L. Wilson, W. L. Conner, C. B. Cochran, H. C. Coppedge, and C. I. Vermillion). U. S. 2,118,908, May 31, 1938 (Aug. 1, 1936).

Recovery of sulfur dioxide from gases. R. F. Bacon. Brit. 478,544, Feb. 2, 1938 (Dec. 24, 1935).

Treatment of aluminous siliceous material. Electric Smelting & Aluminium Co. Brit. 482,326, April 6, 1938 (June 11, 1936).

Uniting ceramic surfaces with one another or with metal surfaces by soldering. Siemens & Halske A.-G. (Hans Vatter, inventor). Ger. 656,457, Feb. 5, 1938; Cl. 80*b*. 23.01; *Chem. Abs.*, **32**, 3569 (1938).—The surfaces are heated to above 300° and then coated at the parts to be united with a hard solder in a finely divided form. This may be effected by applying to the surfaces an aqueous or alcoholic suspension of the solder or by spraying the fused solder onto the surfaces. The solder may be Cu or a Cu-Zn or Cu-Sn alloy.

OFFICIAL PERSONNEL OF DIVISIONS, 1938–1939

	Art	Enamel	Glass	Materials and Equipment	Refractories	Structural Clay Products	Terra Cotta	White Wares
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2nd Vice-Chairman			W. R. Lester					
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